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## THESIS

AN ANALYSIS OF FRIENDLY INPUT DEVICES FOR THE  
CONTROL OF THE  
NAVAL WARFARE INTERACTIVE SIMULATION SYSTEM (NWISS)

by

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March 1986

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An Analysis of Friendly Input Devices for the Control of the  
Naval Warfare Interactive Simulation System (NWISS)

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## ABSTRACT

This thesis describes an experiment conducted at the Naval Postgraduate School (NPS) during the period 15 October 1985 through 28 October 1985. Specifically, the experiment evaluates "pull-down window" microcomputer technology, continuous speech recognition equipment, and standard computer keyboard entry to input commands in a command and control environment. Using the Naval Warfare Interactive Simulation System (NWISS) as a controlled medium, military problems were posed to test subjects in specific light and noise environments.

Although the results are not entirely conclusive, they do demonstrate a distinct advantage in using continuous speech or keyboard entry modes over the drop-down window technology of the Macintosh (if subject training time is not a significant restriction). Either the continuous speech, or the keyboard method was clearly superior in all environments.

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## I. INTRODUCTION

### A. OVERVIEW

Computer Technology has increased exponentially over the past several years. As a result, work is now being completed more efficiently and inexpensively than ever before. Nevertheless, faced with a myriad of available computer options, it behooves the individual user to choose one that is not only user friendly, but is both cost effective and a proven performer. Time has always been a critical factor for any business, and people are now realizing that using a computer only constitutes the first step toward achieving reductions in this area.

In recent years there has been a movement afoot to simplify the all important man-machine interface which counts so heavily in on-line efficiency computations. While the computer keyboard has long been the industry standard, its speed is severely limited by the skill/training of the user; and the subject's knowledge of the particular command keys. Due primarily to these recognized limitations, more attention is being paid to a faster, and more sophisticated means of communication between user and machine: Automatic Speech Recognition (ASR). This concept was first introduced in the late 1950's, and significant progress was made within the last 15 years. It is known that free speech, in its natural form, is the fastest and most economical means for homo sapiens to communicate amongst themselves. Applying this fact to the user-machine interface dilemma, it has been shown that machines can not only be taught to respond to any language, but that

speech for this type of communication leaves the user's hands and feet free in order to perform important concurrent functions (i.e., viewing graphics screens or decision support aids, personnel interface, etc.). While admittedly the progress toward an economically feasible voice recognition system has been slow, ASR products are now making themselves known in industrial, military and security-oriented applications. It is this encouraging trend, coupled with the significant accomplishments in each area of use that leads researchers to believe in its unlimited potential. [Ref. 1 and 2]

The newest development in interface technology is the "pull-down window" incorporated in the Macintosh microcomputer. (See Enclosures 1-6 in Appendix G.) This methodology, in conjunction with the use of a mouse peripheral input device, presents a "rectangular-shaped menu" on a computer screen within which the user writes and reads data representing a program in the computer. Because the movement of the cursor matches the movement of the mouse, the user need only place the cursor on the desired command and press a conveniently located button for instant activation. Although no comparisons (individually or collectively) have currently been made with the more traditional interface devices because of its recent emergence in the marketplace, its ease of use and efficient operation bear true witness to its untapped possibilities. [Ref. 3]

This thesis is concerned with evaluating the speed, accuracy and efficiency of the three previously described input devices. The data gathered for analysis was generated by subjects



participating in an experiment using the Naval Warfare Interactive Simulation System (NWISS), and will be discussed in detail in later sections.

## B. SCOPE OF THE THESIS

Although numerous experiments concerning automatic speech recognition have been conducted at the Naval Postgraduate School (NPS), Monterey, California, only one previous experiment (conducted by Wright and Manson; two NPS graduate students) has attempted a comprehensive evaluation of computer input technologies in a military command and control environment. That experiment was the first attempt to evaluate two voice recognition systems of differing technologies, besides the more conventional keyboard (typing) mode of input. [Ref. 2]

Accepting the conclusions drawn in the Wright/Manson thesis as a basic premise, the Discrete Voice System (Threshold) was eliminated as a possible candidate for further experimentation. This decision was based on its record of poor performance in the experiment, and the requirement of a discrete system to speak in broken phrases which is unnatural and cumbersome to human beings in general. Since the keyboard was highly successful as an input medium in the previous experiment, the results were used as a third comparison against the two newer mediums selected in this experiment. Because the Wright/Manson experiment used the same NWISS wargaming scenarios, it was not only unnecessary to repeat the procedure, but it allowed for more concentration on the exploitation of the possibilities present in the "newer media".

The basic purpose of this experiment was to evaluate different input interfaces to the NWISS wargame scenarios resident on the Digital Equipment Corporation's VAX 11/780 computer. Having selected the appropriate input media (i.e., the Macintosh micro-computer with drop-down window technology, the VERBELX 3000 unit with Automatic Speech Recognition capability and the peripheral keyboard attached to the VAX computer), it was necessary to establish certain Measures of Effectiveness (MOE's) on which to base the ensuing comparisons. It was decided that the number of commands entered during one NWISS wargaming session would be the primary MOE. This coupled with the number of Control\_K's (entry errors made by the user) entered would provide the necessary data in which to answer the following questions: 1) Was any system more effective, and or easier to use?; 2) Was any system more effective under the varied environmental conditions?, and 3) Was a clear learning curve established as a result of more practice with a particular input device?

This thesis will not include a description of the construction process used to devise the wargaming scenarios, or provide the methodology used to build the operating system; since they both already exist. Additionally, the development of the VAX 11/780 and the resident NWISS is already complete and will not be discussed. All conclusions from the experiment and the author's recommendations for follow-on experimentation/study succeeds the analysis of data, and will provide some insight for the future use of this burgeoning technology.

## C. SUMMARY

This thesis comprises a description of the initial experiment, including all procedures and background material preceding its inception. A summary of basic speech recognition technology, Macintosh microcomputer technology and a review of past experiments with speech recognition at NPS is provided in Chapters II and III. The design process for this experiment (i.e., design of the scenarios, determination of environments, background of the subjects, and practice/training sessions) is given in Chapters IV, V and VI. Analysis of the data from the experiment is provided in Chapter VII. All experiment conclusions and the authors' recommendations for further study/applications follow the analysis of data section.

Appendices F and G provide detailed guidance for follow-on experiments using Verbex 3000 or Macintosh microcomputer technology, respectively.

## II. SPEECH TECHNOLOGY

### A. INTRODUCTION

The use of Continuous Speech Recognition Systems has expanded significantly over the past three to five years. After first finding success with discrete systems, ASR is now being introduced for use in critical areas of operation. The progress made in recent years is measured in many different ways. The most obvious is the performance and capabilities of the machine. Some of the other criteria, however, are equally important. These would include increased vocabulary size, distinguishing between easily confusing words and minimizing the effects of noise and other interfaces. This chapter will discuss some of the theory behind Continuous Speech Recognition Systems.

### B. DEFINITION OF TERMS

The real meaning of speech recognition may seem intuitive, but its derivation and appropriate applications will be described further to preclude possible confusion, and to provide a common base for universal understanding.

Speech Recognition can be defined as the process of transforming the continuous acoustic speech symbol into discrete representations. These symbols may be assigned proper meanings, and when comprehended, may be used to affect responsive behavior. The next major distinction is made between Connected (Continuous) Speech, or Isolated (Discrete) Speech. Connected Speech is that in which there are no significant pauses. An example would be a



sentence spoken at a normal rate. It is a difficult task for computers to distinguish between where one word ends, and the next word begins. Isolated speech does not have this problem, since significant pauses (i.e., Turn--Latency--On) are often enough to allow distinction. The "bottom-line" goal of any computer system is to rapidly and accurately interpret the user's input, and then select and respond appropriately. There is no doubt that it is easier to make computers recognize words spoken in isolation, or at worst, spoken in broken phrases. In fact, there are several examples of this on the market today. By the same token, however, speaking with isolated words or broken phrases is difficult for humans to achieve, and hence not desirable. [Ref. 4 and 5]

### **C. CONTINUOUS SPEECH RECOGNITION BACKGROUND**

As the cost of equipment declines, Continuous Voice Systems are receiving increased attention. Concentrated research started in 1971 when the Advanced Research Project Agency (DARPA) of the Department of Defense allocated \$15 million dollars toward a program called Speech Understanding Research (SUR). It was the largest single project ever undertaken in speech recognition, and succeeded in developing machines that were capable of "understanding" continuously-spoken sentences involving a 1000-word vocabulary. [Ref. 6] Although the DARPA project was not the first to research continuous speech recognition, it spawned the ideas of several other companies who followed suit shortly thereafter.

The DARPA project came to an end in 1976 with a long-awaited demonstration of several new systems that could understand continuous spoken sentences. Even though the results were far from perfect, they were extremely enlightening. The Harpy System for example, far exceeded its design goals by correctly understanding 95% of the sentences spoken by five speakers. It used a 1011-word vocabulary, and a highly-constrained grammar of sentences relevant to a task concerning the retrieval of documents from the computer memory.

In 1973, IBM developed a system for automatic recognition of continuous speech that correctly recognized 96% of the 7 digit numbers, with a per-digit accuracy rating of better than 99%. In 1976, Texas Instruments developed a system successful in verifying the speaker's voice before permitting access to the medium itself. [Ref. 6]

At present, there is a great desire to improve the quality of continuous speech recognition technology. Due primarily to its increased speed, naturalness and mobility, researchers have recognized its importance in many varied applications (i.e., Air Traffic Controller training, key word identification in monitored conversations, command and control environments, cockpit communications, etc.), and the necessity to exploit all capabilities.

#### **D. TYPES OF EQUIPMENT USED**

The NWISS was the nucleus of this experiment. In addition, the VERBEX 3000 and the Macintosh microcomputer were configured for use as two of the experimental input mediums, and the peripheral

keyboard attached to the VT102 terminal of the VAX 11/780 used as the third.

#### 1. Continuous Speech Recognition Equipment

The VERBEX 3000 is currently the "state of the art" regarding Continuous Speech Recognition Systems. It is designed for use in industrial and commercial applications, and works well in both high and low noise environments. The system is capable of recognizing natural continuous speech of infinite length, and an output buffer of 240 characters per recognition set is its only limitation. [Ref. 7] With a maximum of four speech processing boards, the VERBEX 3000 can recognize up to 360 different words spread over as many as 20 different grammars. A finite limit to grammar size, based on the total number of words and complexity of the node transition network, is necessary to allow the device to remain "real-time" in terms of computation speed and memory (i.e., stored voice patterns) requirements. Thus, the total application may involve up to 360 words, but at any instant the recognizer is dealing with only one grammar subset. [Ref. 8] The VERBEX 3000 system includes the Speech Application Development System (SPADS). This system allows the user to run applications/software other than those produced by VERBEX 3000. Nevertheless, any program must be written in the programming language Pascal in order to effectively control the application. It is through the use of SPADS that Lombardo (an NPS graduate student) was able to develop a program in which voice commands were used in conjunction with the wargaming scenarios used in the

NWISS. [Ref. 8] Additional equipment for the VERBEX 3000 includes a small speech unit which prompts the user for the next word or phrase. This unit will echo the command if subsets of phrases are needed to complete the command. The subjects in this experiment used a Shure SM12A headset (close-speaking) microphone (as the dedicated input device), and the Siegler ADM 31 terminal to link the VERBEX 3000 system with the VAX 11/780. This particular terminal echos all user inputs including commands and errors identified as Control\_K's.

## 2. Laboratory Equipment

This experiment required three input/output terminals (VT-102 series), three status board terminals (VT-100 series) and three Ramtek color graphic display terminals. The three input/output terminals were assigned as control, umpire and master. Each subject (as well as the umpire) had a color graphic display to view the scenario in progress. Status boards for the two subjects provided accurate combat information for the respective forces, and the umpire had access to all information on a special status board configured for that purpose.

## E. PREVIOUS NAVAL POSTGRADUATE SCHOOL STUDIES

In the past several years, there have been a multitude of experiments and theses developed at the NPS to realize the potential and limits of Speech Recognition. This section will review the findings of a few of these studies as an attempt to summarize the progress to date.



In 1981, research occurred which analyzed speech recognition as a means to improve speed and reliability in the task of imagery interpretation. The purpose of the experiment was to allow an officer to devote more time to concentrate on the object being identified, and less time inputting the information on the keyboard. A discrete voice system (i.e., Threshold, T600 equipment) was used to conduct the experiment, and the analyst found that the voice system was approximately 50% faster than typed data entry. As far as "reporting accuracy", no significant differences were noted. [Ref. 9] Concurrently, in 1981 a NPS student studied the practicality of using voice systems in a war game environment. The objective here was to play the game scenario utilizing a discrete system (T600) and a standard keyboard. Performance measures that were evaluated included time required for each input, and the number of input errors. The game, entitled Warfare Environmental Simulation (WES), (later evolved into NWISS) provided the interactive, real-time wargame used in this experiment. The student's experiment suggested that the keyboard entry was faster and resulted in fewer errors. [Ref. 10] Why then was there a difference in outcomes between these first two studies? Apparently, the method of measuring the errors was different in the WES experiment. The total errors for the voice entry included recognition and operator errors, while the keyboard entry totals only included the typing errors. For the imagery interpretation experiment, the methods used to measure errors for both input devices was identical.

Several other experiments using discrete systems were conducted with similar results. The "better" method depended on the designated MOE, the experience level of the subjects, the extent of the training of the subjects, etc.

In 1984, another NPS student developed a thesis that attempted to evaluate the use of continuous voice recognition technology in a wargame environment. The student developed the application software to run the NWISS wargame using the VERBEX 3000/continuous speech system. This software became the foundation for the Wright/Manson thesis; the final thesis before this experiment. The authors of the thesis, Wright and Manson, evaluated the effectiveness of three input devices (continuous speech, discrete speech and the standard keyboard) while running the NWISS wargame. The nonintuitive conclusion suggested by Wright and Manson was that the keyboard players did better overall. Further research gave some possible plausibility for this result. During low light sessions almost all the keyboard subjects moved the keyboard panel closer to the CRT to alleviate a perceived handicap. A post experiment survey also revealed that the keyboard group had the highest typing skill level of the three groups. Additionally, the discrete system fared well below the other methods in the majority of the comparisons, and even though shorter training was required, incorrect recognition was more likely to occur under varying levels of ambient noise and dissimilar user voice patterns.

From the results obtained in the Wright/Manson thesis it can be ascertained that while the keyboard still remains an alternative

for computer interface, the discrete system (however effective it may be) is not natural to an individual's way of speaking, and does not merit further investigation. Concurrently, it is also recognized that more evaluation of the continuous speech recognition system is needed, and it shall be discussed further in later chapters of this thesis.

## **F. PROBLEMS OF SPEECH RECOGNITION**

With any field of study there are many problems which tend to hinder the progress of new technology; and Continuous Speech Technology is no different in this regard. Nevertheless, several additional factors must be considered when human behavior is involved. For instance: Can an inexperienced user operate a voice system? Will the system accurately recognize an individual's voice signals? In general, the bigger the system's vocabulary capacity, the more prior training will be required. Also, if a large number of sentences and alternative phrases need to be recognized, additional training may be necessary. The vocabulary itself plays an important role in determining the systems ability to recognize utterances with any degree of consistent accuracy. In other words, it is much easier to recognize 100 distinct words, than to recognize 100 "rhyming" words/phrases (i.e., a "light house" vs. a "lighthouse").

Another difficulty occurs when there are "highly constrained" sequences of words (i.e., stock numbers, telephone numbers, etc.) or carefully formatted phrases (i.e., air traffic control commands, fixed-length commands with each word selected from a predetermined

vocabulary, etc.). These words or phrases require a more complete analysis to insure the proper context of each word. It is also extremely important that the speaker articulate/annunciate each word in the command.

One of the biggest difficulties encountered when dealing with speech recognition is the unwanted ability of the microphone to pick up outside noise, or sounds from the environment. While it is a fact that real life conditions may encounter additional noises causing degradation in the systems ability to accurately recognize words, the judicious use of available testing facilities will allow optimum conditions on a regular basis. Another possible solution is to use "close-talking" microphones or headsets. These particular devices are able to differentiate between nearby sounds and sounds heard at a distance. [Ref. 6]

Cost is another very common problem with this technology. For Research and Development companies and commercial users, the initial cost is very high. At this point in time, the demand for continuous speech recognizers is not enough to stimulate the significant number of grants and contracts necessary for adequate research.

The question that is uppermost in the minds of many commercial investors is not whether the equipment is affordable, but is it necessary? Do we really need a continuous speech recognizer? Some people argue that "isolated word recognizers" are adequate for most jobs. The fact still remains there is little doubt that if improved, the sheer mobility and flexibility of continuous

speech systems would easily surpass the cumbersome operation inherent in discrete systems.



### III. MACINTOSH MICROCOMPUTER TECHNOLOGY

#### A. INTRODUCTION

Although the odds against its fruition seemed monumental in 1979, the Macintosh microcomputer, designed by a small group of inexperienced engineers and programmers, is now recognized world-wide as a technological marvel in personal computers. Relying heavily on symbols and associated pictures on the screen, it is designed primarily to help people conquer computer phobia and be as easy to use as a television set. It is this ease of use attribute that made it so attractive as a possible testbed interface device for wargame simulation. [Ref. 11]

This chapter will focus on some of the terminology inherent in microcomputers, described the origin/background surrounding Macintosh's innovative technology and its adaptability to experimental design, and lastly, describe the equipment that was used in the experiment.

#### B. BACKGROUND

The Apple Corporation's Macintosh microcomputer is built on three (3) primary ideas:

- 1) second-generation Lisa technology (an expensive desktop computer designed for commercial use that pioneered the merging of graphics and "mouse"-oriented peripheral operation),
- 2) reliability and low cost through inbred simplicity, and
- 3) a maximization of the synergism possible between hardware and software.

Powered by the dedicated ambition of Burrell Smith (a former Apple Computer Corporation maintenance technician) Steven Jobs (the chairman of Apple, and the Macintosh project director) and an elite project team of "visionary radicals", Apple has succeeded in creating a machine that weighs only 20 pounds, can be carried in a tote bag and has many of the significant features introduced in January of 1983 with the Lisa computer. Although it uses a "mouse" (a pointing device roughly the size of a pack of cigarettes) that permits users to give commands to the computer via arm/hand movements and button pushing, there are four (4) basic differences from the Lisa that make it second-generation oriented:

- 1) a much higher clock speed (7.83 MHZ vs. the Lisa's 5.0 MHZ),
- 2) smaller memory used more efficiently through the MC68000 processor,
- 3) an elimination of add-on peripheral cards through the extended use of a high speed serial bus coupled with the implementation of "virtual slots", and
- 4) it allows only one applications program to be active at a time (an important limitation).

Although this latter limitation aspect seems serious in nature, it actually facilitates the use of multiple window operations and allows material to be "cut and pasted" from one document to another by a "clipboard" arrangement. Nevertheless, the absence of hardware slots and the lack of ability to run two simultaneous applications are the two important separation criteria from that of the Lisa technology. [Ref. 12]

By combining the functions of many standard chips into eight programmable logic arrays, it makes it possible for the Macintosh to keep its chip count (and therefore its price) relatively low, while simultaneously producing a machine that has a reliability factor characteristically associated with much simpler computers. With only two printed circuit boards, it was cleverly designed to eliminate the need for hardware fine-tuning during assembly or use. It is this combination of reliability and simplicity that makes it an ideal training or input interface.

The Macintosh's hardware and software are fully optimized for maximum potential. This simply means that the hardware and software have evolved slowly over a period of time that has provided a mutual "give and take" association. As a result, the video display hardware design greatly simplifies the software design; allowing it to easily draw squares and circles, scale text and graphics and print screen images. Utilizing this feature to its fullest, Tom Concannon (a NPS graduate student) was able to develop the NWISS wargame interface program in the BASIC language to allow the experiment subjects to play the various wargame scenarios. This program activated the "user toolbox", which is primarily responsible for manipulating all the various relative relationships between different units/accessories in the MC68000 processor. By stimulating the window and menu managers, the subjects were then able to use the mechanical mouse to select wargame commands from a two-dimensional matrix of menu items. The selected input was coordinated through a resource manager facility which perpetuated

the eventual interface necessary for communication and command actuation on the VAX 11/780 computer. An example of each menu column followed by all the possible user selections is contained in the pictorial section of the Macintosh Microcomputer User's Guide (see Appendix G). [Ref. 3]

### C. EXPERIMENT HARDWARE DESCRIPTION

The Macintosh has received numerous accolades for its impressive design. It is truly a highly developed microcomputer that effectively uses a mechanical mouse peripheral and a 32 bit microprocessor in a lightweight portable package. It is its portability, functional simplicity and ease of use that make it the ideal selection for a user interface device.

The Macintosh microcomputer is a self-contained unit (9.75 by 9.75 by 13.5 inches) consisting of a main unit, keyboard and mechanical mouse. It uses standard AC external power, has two serial ports and an integral Sony 3.5 inch disk drive which holds up to 400 Kbytes of information. Its standard 128 Kbytes of RAM, and 64 Kbytes of ROM were reconfigured before the actual experiment to 512 Kbytes to accomodate the slight command entry delay experienced by users at the lower configuration setting. The nine (9) inch monochrome monitor provided an adequate display of all pictorials, and its 58 key detachable keyboard served as a comfortable medium for a backup typing input mode. The main source of user input was a small mechanical mouse which is physically moved in a rectangular series of hand movements to position an onscreen arrow to the desired menu. Keeping the index finger positioned on

a conveniently mounted button, the user manipulated the mouse to position the arrow, and used the button to extend the desired menu and select the appropriate command for subsequent implementation. A detailed description of the mechanics involved in user operation is again available by referencing Appendix G. [Refs. 13 and 31]

RAMTEK high resolution color graphics monitors were used to display the game scenarios to the subjects at their respective positions, and the digital VT100 terminal was used as a status board for each NWISS session. The configuration of the laboratory itself will be further described in Chapter VI, and a pictorial display of the physical layout provided (see Figure 6.1).

A conventional cassette tape recorder was used to play a pre-recorded background noise tape during each NWISS session. One eight inch, eight ohm speaker was placed at a pre-established distance from each subject, and an audiometer was used to verify the decibel settings for each light/noise environment specified. The pre-recorded noise consisted of a gathering of approximately thirty (30) people speaking in a conversational tone within an auditorium. [Ref. 2]

#### **D. SUMMARY**

This chapter has served to discuss some of the terminology inherent in the design/description of the Macintosh microcomputer, and has presented some of the background theory and history behind its origin. Although there were no previous wargame scenario experiments conducted at the NPS involving the use of the Macintosh



(or similar technology) as an input medium, its ease of use, and its overall potential prompted its employment in this experiment. Finally, a description of the actual microcomputer hardware and associated laboratory equipment included in the experiment was provided.

#### IV. THE NAVAL WARFARE INTERACTIVE SIMULATION SYSTEM (NWISS)

##### A. INTRODUCTION

This chapter contains a brief description of NWISS and its support role in this experiment. All scenarios developed for the experiment, the measures of effectiveness selected and the methods used to collect data and compare the two command input technologies are also described.

##### B. WHY NWISS WAS SELECTED

NWISS is a real-time, user-interactive simulation of naval warfare. Its mission was originally to train senior Naval Officers in force-level tactical decision making and management of command and control. At the Naval Postgraduate School, NWISS resides on a VAX 11/780 computer, and the peripheral VT100/102 terminals and RANTEK graphics terminals provide the necessary input/output modules when grouped together. Voice equipment (i.e., the VERBEX 3000), and "drop-down" window microcomputer technology (i.e., the Macintosh microcomputer) were used as interface devices in the available modules, and all inputs and outputs were accomplished by trained subjects. NWISS was loaded, controlled and monitored from a third "command" module during these experiments. The purpose of NWISS in this experiment was to stimulate a stressful environment that would allow user intervention via NWISS commands. From the user's point-of-view, it has a large vocabulary of commands to change the view of the tactical situation in the battle arena, cause changes in the course and speed of vehicles

in one force, and launch air assets with user defined weapon loads and missions. NWISS can also show the status of the user's forces on several menu selected displays. For this experiment, each station consisted of a command input terminal, a force status terminal and a video monitor to graphically display force disposition and identity. [Ref. 2]

NWISS was used to support this experiment because it:

1. Offered the ability to present identical tactical situations to two isolated subjects simultaneously. This controlled environment allowed a side-by-side comparison of the command input methods chosen by the isolated subjects when confronted by identical tactical stimuli. Additionally, the system was readily available at the NPS, and a pool of trained operators were accessible for "on-line" consultation.
2. Provides a large system vocabulary. Consensus of opinion was that if a small vocabulary was chosen to run the experiment, the subjects may become bored through sheer command repetition. Approximately 150 words/utterances were deemed necessary to properly conduct the variety of inherent missions within the capabilities of an Aircraft Carrier Battle Group. Twenty commands relating directly to the control of the tactical force display were also included. Tables of the complete vocabularies for the two input technologies are included in Appendices F & G. These vocabularies were predetermined and were limited by the size of the memory of the VERBEX 3000 system. Using the forces and commands in these subsets of the NWISS dictionary, four previously developed scenarios were used as a medium for stimulating subject interest, and for generating a meaningful MOE. [Ref. 14]

In all four scenarios, the Orange and Neutral force actions, defensive posture and radar emissions control (EMCON) status were preprogrammed. Orange aircraft were eliminated from this experiment, to avoid unnecessary system program complexity. The two available views of the world for the Blue forces were simulated on approximately the same latitude, but were physically separated in longitude by 500 nautical miles at mid-ocean.

NAISS is limited to a maximum of six sets of forces, and the Orange and Neutral forces were each structured appropriately to reflect one view. The specific process for assembling these various views and overlapping them is explained in some detail in a previous NPS thesis by Owens and Brown. [Ref. 15] Basically, there were two separate views for the Blue forces which allowed the subjects to individually control their own ships and planes.

## C. SCENARIOS

Four unique scenarios were used in order to effectively place subjects in situations requiring the use of the available NAISS vocabulary, and to stimulate individual/different responses. This section describes the basic opening force positions for each of the scenarios and the accompanying military situation briefing for that scenario. The actual situation briefings given to the subjects are included in Appendix A.

### 1. Scenario A

One aircraft carrier, twelve P3C aircraft, two frigates, and an attack submarine are assigned to the Blue forces. Orange forces include one aircraft carrier and six surface combatants, and are escorting eight neutral merchant ships in a convoy that is moving south as shown in Figure 4.1. The merchant ships are reportedly carrying nuclear and chemical weapons to an unidentified Orange ally. Hostilities have been declared between the Blue and the Orange forces and the objective is to identify and destroy the Orange escort vessels without involving/destroying the merchant ships.

## 2. Scenario B

Blue forces consist of two P3C aircraft to provide the necessary targeting information, one aircraft carrier and two flights of five attack aircraft. Four Orange surface combatants are positioned between these Blue forces, and twenty merchant vessels are at anchor outside a fictitious harbor facility waiting to unload their cargo. Hostilities have not been declared between Blue and Orange forces, although tensions remain high. The Blue force's mission is to use the assigned airborne aircraft, and the remaining aircraft carrier based assets to conduct a strike on the merchant vessels. Rules of engagement do not permit firing by the Blue forces until the Orange forces have fired on them. From the opening positions as shown in Figure 4.2, neither the merchant ships nor the Orange combatants are visible to the Blue forces, but a northerly course is dictated by the mission.

## 3. Scenario C

A favorable environment is present in which Blue tasking is to locate and identify as many objects as possible and designate them as Friendly, Neutral or Enemy. Blue forces have one P3C and four F14A aircraft to accomplish this mission, and Combatants for both Blue and Orange forces, as well as several merchant ships and fishing vessels, are all in a 400 X 500 nautical mile rectangle (as depicted in Fig. 4.3). No control of the Blue surface forces was permitted to complicate the tasks of location and identification.








#### 4. Scenario D

Two carrier battle groups of approximately equal strength are pitted against each other. Blue forces are specifically tasked to locate and identify the elements of the Orange force battle group. Hostilities have not been declared, but the subjects were allowed wide latitude in their response to any Orange force aggressive action. The opening positions in Figure 4.4 place the Orange force carrier battle group to the North of the Blue force group; with the Orange force headed North and the Blue force headed to the Northwest.

#### **D. MEASURES OF EFFECTIVENESS**

All subjects were familiar with the NWISS wargaming scenarios. Some of the commands (i.e., changing the scale of the display) were easy to accomplish and rapidly assimilated, while others (such as the launch sequence) required patience and considerable practice to implement correctly. When the subjects received their mission briefing before each session, they were told some of the measures of effectiveness by which their success or failure would be determined. Included were such things as the number of merchant vessels sunk or damaged in Scenario B, the number of ships correctly located and identified in Scenario C, and the number of Blue forces lost to hostile fire in Scenario A (see Appendix A). In each case, the subject was urged to accomplish the goal within the allotted time period (i.e., 40 minutes). These MOE's were false sets of MOE's, and although not used for analysis, were intended to stimulate the subjects to achieve a meaningful goal.

LEGEND:  BLUE SURFACE COMBATANT  
 BLUE SUBMARINE  
 ORANGE SURFACE COMBATANT  
 BLUE AIRCRAFT  
 NEUTRAL MERCHANT SHIP

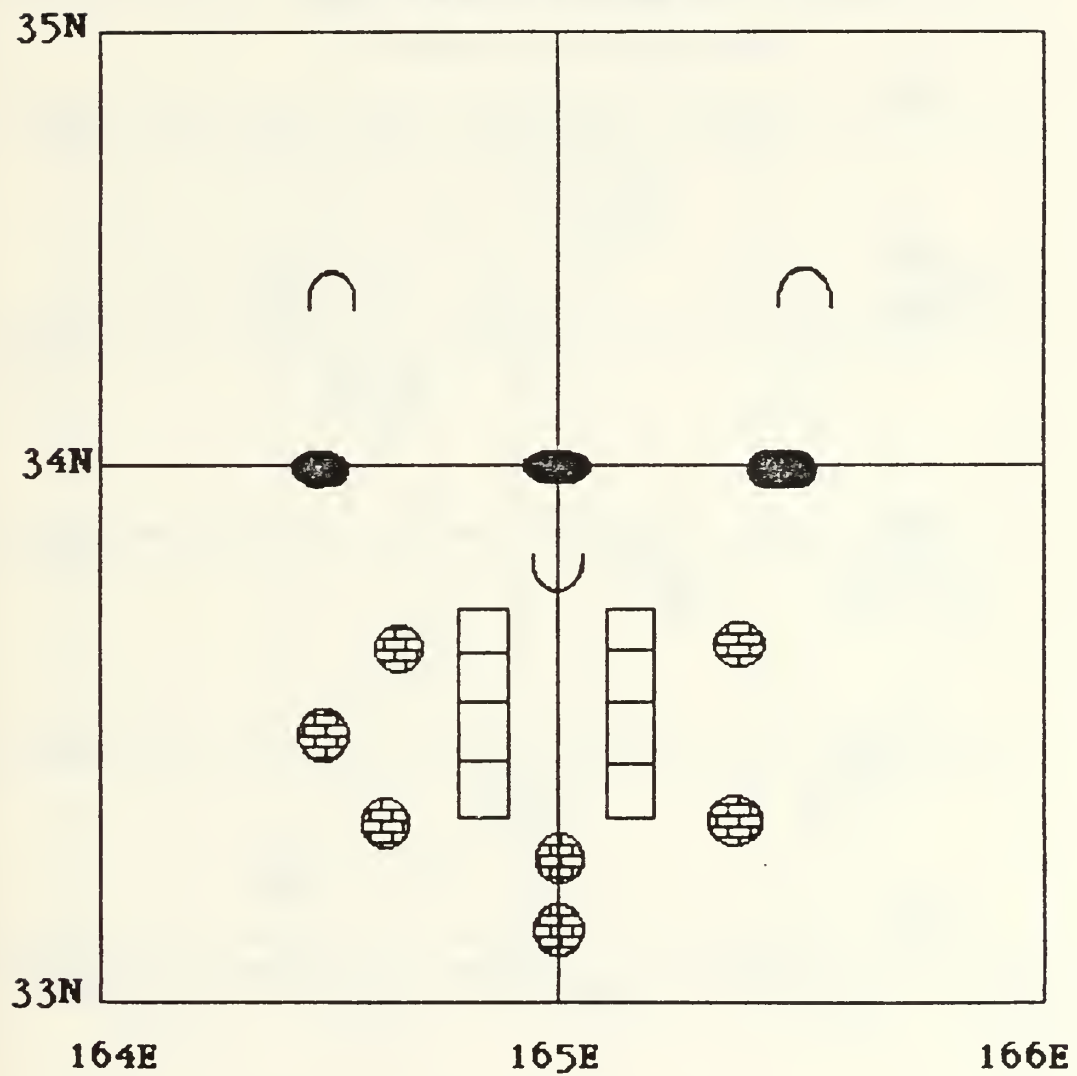






Figure 4.1 Scenario A

LEGEND:  BLUE AIRCRAFT  
 BLUE SURFACE COMBATANT  
 NEUTRAL MERCHANT SHIP  
 ORANGE SURFACE COMBATANT

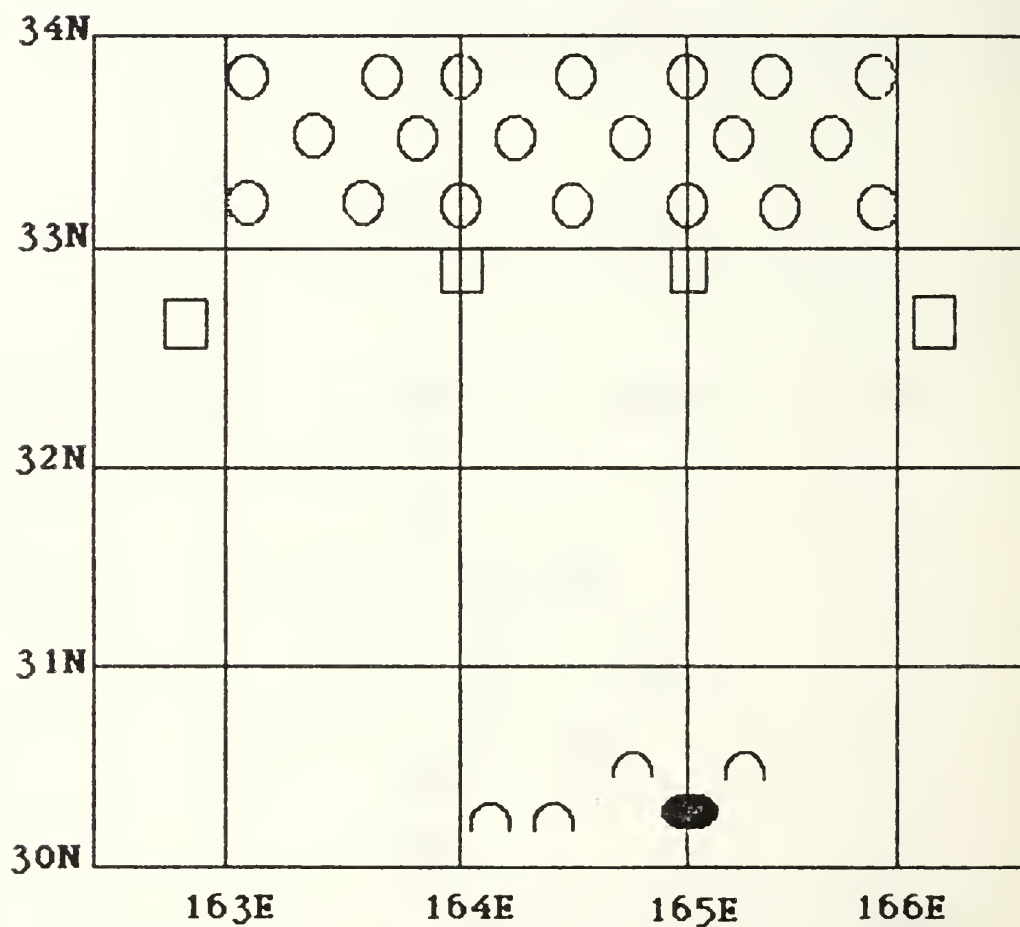






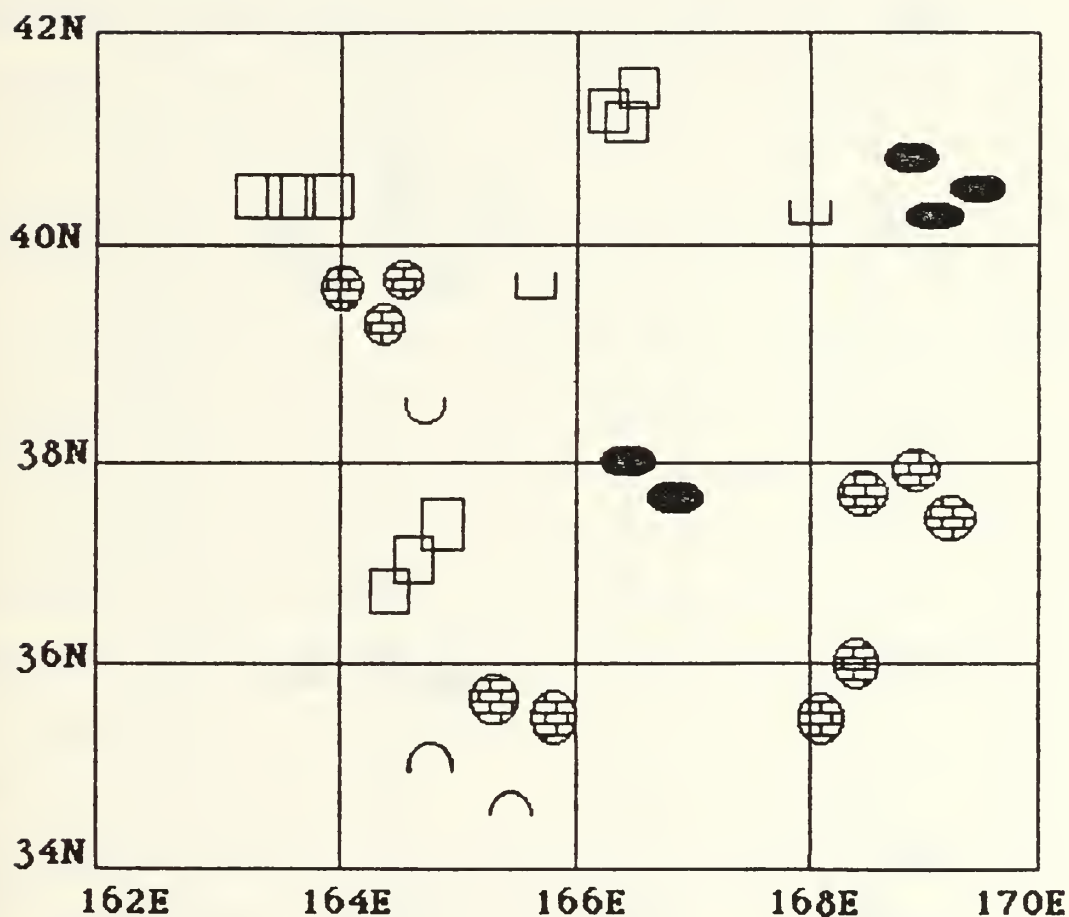






Figure 4.2 Scenario B

**LEGEND:**  **BLUE AIRCRAFT**  
 **BLUE SURFACE COMBATANT**  
 **BLUE SUBMARINE**  
 **NEUTRAL MERCHANT SHIP**  
 **ORANGE SURFACE COMBATANT**  
 **ORANGE SUBMARINE**



**Figure 4.3 Scenario C**

LEGEND:  BLUE SURFACE COMBATANT  
 BLUE SUBMARINE  
 ORANGE SURFACE COMBATANT  
 ORANGE SUBMARINE

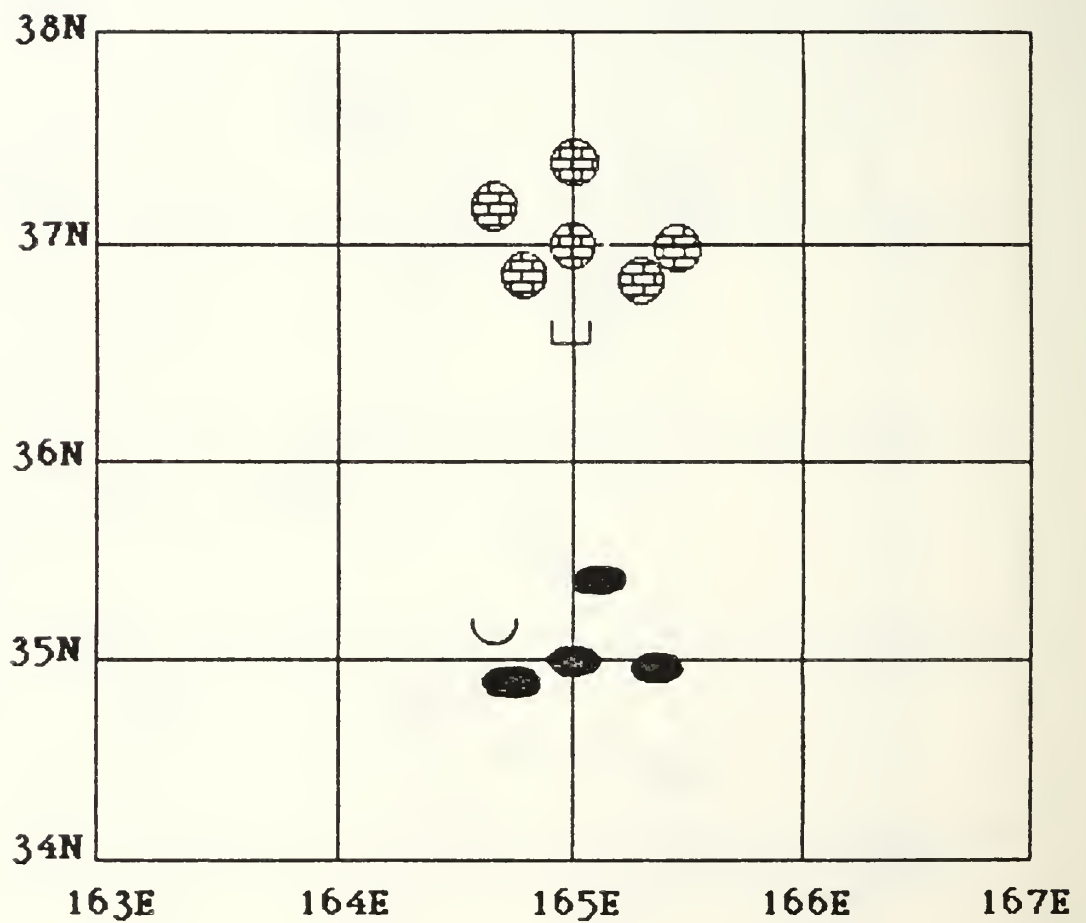


Figure 4.4 Scenario D



The **actual** measures of effectiveness are related to the number of NWISS commands entered and their corresponding accuracy. The number of commands entered was considered to be the most precise indicator of subject mastery over the input technique. It was felt that the four scenarios, with the applicable combinations of light and noise levels, provided the opportunity for the subject to use commands available under varying environmental conditions. Real-world time constraints and accompanying pressures were impressed on the subjects by the schedule, and by the deliberate, overt actions of the facilitators. Since all the sessions lasted the same number of game minutes, the number of commands entered was essentially a rate of entry. The astute subject could have increased this rate significantly simply by repeatedly varying the display radius. By stressing the fictitiously generated MOE's, this type of performance was indirectly discouraged.

It was determined through supervisor consultation and group advisory discussion that accuracy can be measured to some extent by the number of times the "Control\_K" command is used to delete an attempted command. Nevertheless, there are some limitations to using "Control\_K" as a measure of the number of errors made by subjects. Since it aborts the current command and does not execute it, the "Control\_K" could be viewed as a change of mind on the subject's part. From prior experience with the NWISS game it is as easy to enter a completed command and issue a subsequent correction, as it is to abort the command completely. [Ref. 2] There are also two equipment related factors that detract from

the use of "Control\_K" as an error counter. First, in the VERBEX 3000 speech recognition system, after the keyboard has been used to enter an NLISS command not included in the 155 word vocabulary, the "Control\_K" command is necessary to return to the beginning of the command input sequence. Therefore, this use of "Control\_K" does not indicate an error, but the correct use of the system. Secondly, it could be that the subject's utterance/word was not recognized by the system and the subject elected to enter the command manually. The result is the same as in the first case: the abort command must be used to return to the start of a new command input sequence. In a deliberate attempt to alleviate this particular "discrepancy", the authors' evaluated the printout of the sessions immediately following their execution so that memory of the subject's rationale behind the selection of a Control\_K input could be interjected, and subsequently discarded if it was not intended as an error correction. Overall, despite these considerations, it was felt that the "Control\_K" command provided the best measure available of errors made in entering commands; although it still may not be as strong a measure as the number of commands entered.

#### **E. DATA COLLECTION**

Data collection was accomplished through several utility programs of the VAX 11/780. All commands entered by the two subject's command terminals were sent to separate files in memory, as was the record of the umpire's game control terminal. This process provided a record of all subject activity, and kept a

historical account of all engagements, weapon firings and resultant damage displayed on the umpire's terminal for further study. The output was then hand-counted to determine the number of commands entered and the number of errors committed.

One additional comment is warranted regarding how the number of commands entered was actually determined. The aircraft launch sequence is widely used, and is the most lengthy and difficult command. Since the aircraft launch sequence involves at least five lines to be complete, and could potentially be aborted anywhere within those lines, each line of the five that was correctly entered was counted as a command entered.

## **V. EXPERIMENT BACKGROUND**

### **A. INTRODUCTION**

Several independent factors were considered crucial to the success of this experiment. First was the continued operational status of the critical "hardware" (i.e., the VAX computer, the NWISS wargame, the VERBEX 3000 system and the Macintosh computer). Secondly, a total of 24 subjects were needed to participate in the experiment. Decisions such as the length of each session, the randomness of the sequences and the combinations of scenarios and environments were also of major importance. This chapter will describe the actual training and practice sessions using the VERBEX 3000/Macintosh microcomputer technology, discuss the background of the subjects, and elaborate on the details surrounding the design of the experiment.

### **B. BACKGROUND OF SUBJECTS**

The 24 subjects who participated in the experiment had a myriad of backgrounds. Twenty-three of them were armed forces officers (i.e., U.S. Navy, U.S. Army, U.S. Air Force, etc.), and all were studying Command, Control and Communications (C3) at the Naval Postgraduate School (NPS). Nineteen were male and four were female. The twenty-fourth subject was a male civilian computer operator employed at NPS.

All the students participated in the experiment in conjunction with OS 4602, a required Operations Research course titled Command, Control and Communications Systems Evaluation. A previous Operations

Research course, OS 3603 (Simulation and Wargaming), introduced the students to the NWISS background and symbology used for the experiment, and a similar course, OS 3404 (Man-Machine Interaction), introduced them to Discrete Automatic Voice Recognition Theory. All the subjects were familiar with the basic facilities; that is, the digital VT100/102 keyboard terminals and the Ramtek graphics monitors. None of the subjects had ever used a continuous automatic speech recognition system, and some had never used the particular headset-type microphone incorporated by the VERBEX 3000 unit. Additionally, out of all the Macintosh players, only five had ever used a mouse, and due to the specific nature of the software program, it would be the first time anyone had played the NWISS game using that device. The civilian programmer was to be a VERBEX 3000 player, and although he was familiar with the NWISS game, he had never played it using the continuous voice interface.

The 24 subjects were divided into two equal teams of 12 people. Each team would only use one input device (either the VERBEX 3000 or the Macintosh). Selection was made randomly, and on that basis a VERBEX 3000 player and a Macintosh player were partnered so they could be scheduled for each session simultaneously. Similar classroom schedules were the only matching prerequisite, and although the amount of exposure to the NWISS was equal for all subjects, a similar statement could not be made concerning each individuals competence with the same.



### C. ENVIRONMENTAL CONDITIONS

The experiment was constructed to simulate a military command and control center. To accurately represent this, four different environmental conditions were used. One of four combinations of noise and light levels was established for each run of the experiment, and one of four different scenarios was used to allow each player to experience a different set of circumstances and environmental conditions for each individual's wargaming sessions. Additionally, by alternating scenarios it helped to preclude familiarity, and any possible unfair advantage achieved through intimate knowledge of one scenario in particular.

Noise and light conditions used for the experiment are summarily described as follows: low noise (65 db), high noise (85 db), normal lighting (approximately 1 foot-lambert) and low lighting (lights completely out; approximately .05 foot-lambert). The introduced noise was measured in decibels with an audiometer (on the C-scale), and readings were taken at the subject's "ear-level" with the stereo speaker approximately 2-3 feet away. Light conditions were measured with a light meter. Normal light conditions of 1 foot-lambert were achieved by maintaining the overhead track lights on and directed at a 45 degree angle toward the nearest wall. With the lights out in the low lighting setting the only lighting available to the subject was the light emitted from the associated CRT and Ramtek graphics screen.

To the greatest extent practicable, physical partitions were used to maintain the appropriate noise/light conditions throughout

each session. Full cooperation was experienced from the other users of the C3 wargaming laboratory, and a stable, controlled experimental atmosphere maintained (see Figure 6.1, Chapter VI, for a complete Laboratory Layout).

#### **D. SCHEDULING OF SESSIONS**

The NWISS experiment took place in the C3 wargaming laboratory at the Naval Postgraduate School. It was intended to be run in lieu of the subjects scheduled laboratory period for their OS 3603 course. The subjects would participate individually in four sessions; each run was scheduled to last for 40 minutes. A short brief/debrief period would make the entire session approximately 50 minutes in total length.

The experiment was conducted from 15 October 85 through 28 October 85, and during that period a total of 96 sessions were recorded. The C3 laboratory proved to be an ideal location for the experiment. Because the NWISS game is resident on the VAX 11/780, and the VAX, the VERBEX 3000 and the Macintosh computers were all located in the same laboratory, they were all easily configured and able to communicate well with each other.

The experiment was conducted early in the Fall academic quarter to alleviate traffic congestion throughout the laboratory by non-participants. Since the laboratory was divided into three equal bays, each player was completely separated from the other player, and in almost total isolation from other laboratory users.

Actual scheduling was done on a random basis, and changes were only made if conflicts arose between team members. The

cooperation exhibited by the subjects in this regard was greatly appreciated as only a few last minute changes had to be made. See Appendix B for a complete listing of subjects, and the actual experiment schedule of sessions. [Ref. 16]

#### **E. SCENARIO/ENVIRONMENT SEQUENCE**

A separate scenario and environmental condition was assigned for each session, and each team played the NWISS under all four combinations. For example, Team 4 played the NWISS using Scenario A and Condition 4, Scenario B and Condition 3, Scenario C and Condition 2, and finally Scenario D and Condition 1. The order of assigning scenarios was counterbalanced for sequential positioning, and for both preceding and following treatment effects. [Ref. 17] (See KEY in Appendix E.)

The assigning of environmental conditions was also adjusted using the same methodology. The schedule was adhered to as closely as possible, and even with three separate last minute session changes, all subjects played each scenario and environmental condition once.

#### **F. CONSTRAINTS**

Due to its secure environment, and the fact that all the wargaming scenarios were already available on the VAX computer, the C3 laboratory was the perfect place for running military wargames. Nevertheless, certain features inherent to the laboratory itself led to the following constraints during the experiment:

1. NWISS is the only wargame available at the NPS that has the software available to allow the use of the VERBEX

3000 equipment for the input of voice commands. The experiment was therefore constrained to using the VERBEX 3000 system for the continuous voice input.

2. The physical layout of the laboratory itself restricted the placement of the VERBEX 3000 and Macintosh input devices to keep a lighted section of the laboratory open for other student use.
3. The versatility of the laboratory allows it to be used for a myriad of student/instructor projects. Because of this fact the experiment had to be conducted at a time when the laboratory could be exclusively reserved, to prevent interference with the established environmental conditions. As a result, it was necessary to complete the experiment in October. Additionally, the sessions had to be designed to coincide with the regularly scheduled laboratory periods of the OS 4602 students in order not to conflict with their individual schedules. The combination of all these particular constraints prudently limited the actual sessions to four per subject. Each session lasted approximately 50 minutes to allow sufficient time to properly brief the subjects and collect pertinent data.
4. The subjects were randomly selected, and permanently assigned to only one mode of command input due to the previously mentioned time constraints, as well as to increase their personal proficiency with the assigned input device.

## G. TRAINING

### 1. General

As delineated earlier, all students were assigned to either the continuous voice recognition system (VERBEX 3000) or the Macintosh microcomputer located in the C3 Wargaming Laboratory. Each individual was given a thorough briefing on how to use the appropriate device, and how to train the equipment to either recognize their unique utterances of the designated NWISS commands (for the voice), or enter the necessary commands selected from the appropriate "drop-down" display window (for the Macintosh).



## 2. Environment During Training Sessions

Normal laboratory lighting conditions were allowed throughout the training sessions. This normal level of one to two foot-lamberts would be employed during two of the experiment's four simulated environmental conditions, and simultaneously facilitated NWISS phraseology reference for the user's refamiliarization/retention.

A cassette tape supplied continuous background noise at a level of sixty-five decibels. A previous voice experiment had determined a direct correlation between the consistent use of this decibel noise setting and the best possible climate for voice recognition. [Ref. 18] Besides its acceptance as the best noise level for recognition accuracy, it was discovered that the background noise with the presence of a fixed air vent recirculation fan would provide the minimum level of noise present throughout the course of the experiment.

## 3. VERBEX 3000 Voice Training

To allow the VERBEX 3000 system to react properly to the 150 preprogrammed NWISS command words, it was necessary for all designated voice subjects to engage in two specific phases of voice recognition conditioning. The first phase required the consistent repetitious uttering of all 150 words individually in order to allow the VERBEX 3000 unit to logically associate each word with each users unique voice characteristics, and then physically enroll this "transformed" version of the word into its memory for later recall/recognition. This procedure took an



average of 40 minutes for each user, and although a standardized pronunciation of the word was supplied and encouraged , the subjects were free to substitute any utterance they desired for the VERBEX 3000 prompt (if it was remembered and used during the actual wargaming sessions). In the second phase, a maximum of three of the 150 possible utterances were concatenated, and then grouped by similar usage into nine specific grammars or sections. Each partial command phrase was then repeated continuously, and as consistently as possible (using voice inflection and volume control simultaneously ) by the user. By design, each utterance was repeated approximately 20-23 times in different sets within a specific grammar. It was also recognized that although some of the utterances were unique to a specific grammar, commands such as "Control\_K" were common to all grammars, and therefore trained more than the rest. This phase was the most demanding and repetitive in nature, and required approximately 5.5 hours to complete. [Ref. 19]

At the conclusion of the enrollment and training phases each individual received a 30 minute practice session while interfacing with an NWISS wargaming sample scenario. This was a monitored exercise stressing verbal consistency, volume control and familiarization with NWISS commands. For a complete listing of all the grammars, the individual procedures involved with introducing personnel to the environment and all of the individual words that were enrolled, refer to the NWISS/VERBEX 3000 Users Guide, Appendix F.

#### 4. Macintosh Microcomputer Training

While command input accuracy in the voice environment is based on repetition coupled with consistency, the point select method inherent in Macintosh's mouse requires manual dexterity and practiced digit manipulation. To allow the Macintosh user to interface with the wargaming scenario resident on the VAX computer, a program was written in the language BASIC to provide the user with command words from a limited vocabulary. The program simulates the VT100 terminal in that it allows information communicated to the VAX to be displayed on the screen for analysis. It permits the sequential selection of words and limited phrases through an appropriate column header and its associated "drop-down" window; all operated and selected via mouse technology. A capability also exists for the user to enter the manual mode and type commands to the computer using the attached keyboard.

Training for the Macintosh was accomplished in an "offline" mode which allowed the user to make full use of all operational commands, without the response of the VAX computer. Each user was given a 15 minute orientation brief on the use of the mouse, and the subsequent self-generated training in command selection averaged 35-50 minutes.

### **H. PRACTICE SESSIONS**

#### 1. Initial Individual Tasks

After training their individual speech patterns the subjects were given written instructions on how to bring up the NWISS game and initialize the VERBEX 3000 and Macintosh

microcomputer. They were given a list of approximately 50 separate NWISS tasks to perform by issuing commands using voice and the mouse peripheral input. While the lists were different for the continuous and Macintosh inputs because force names and call signs were different, the general set of tasks were the same. The tasks were very specific in nature to require the subjects to put them into acceptable NWISS format, and then enter the commands as a recognizable speech or Macintosh input.

There were several purposes for the individual practice sessions described above; especially for the VERBEX 3000 users. It helped to identify problems with recognition (so that subjects could retrain vocabulary/refresh their memories), and it was useful in teaching subjects to take a general task and convert it into NWISS format. This was especially important for VERBEX 3000 users in that the necessary pauses between phrases were required for the different grammars. Most users initially thought they were having recognition problems, when in fact they were not pausing in the proper places. The authors participated in these practice sessions (one on the VERBEX 3000 and one on the Macintosh) so that a better feel for the problems encountered by the subjects could be experienced first hand. [Ref. 2]

Enhancement of the experimental design was achieved by using subject training that allowed the identification of "obscure" NWISS vocabulary not often trained by the VERBEX 3000 users; or inadvertently overlooked by the Macintosh subjects. There was an additional problem with VERBEX 3000 because while an individual

word may have been trained, it may not have been included in all grammars or phrases. These imposed limitations were taken into account at the scenario design phase by Wright and Manson in their thesis, and since the same scenarios were used in this thesis they were also fully incorporated.

## 2. NWISS Practice Sessions

All subjects went through a practice NWISS session before the actual experimental testing, and (as described in Chapter VI) all subjects were assigned to either continuous voice, Macintosh microcomputer or keyboard entry. There were several reasons for this practice session. Since all of subjects had recently completed a separate classroom experiment using NWISS, it was necessary to refamiliarize the voice users with the names of the forces for which they had previously trained their voice patterns. In addition, it was found that in the majority of cases (due to the large number of students present in each group), all the subjects were not able to rotate through the specific position that allowed them to actually input commands during the running of the session. This sample scenario gave each individual an inkling of the type of commands to be performed during the actual experiment. All subjects had access to status boards showing their available forces, which made the remembering of names less of problem with continued practice.

The practice sessions proved to be very instructive for the authors during the actual preparation for the experiment. These sample sessions used the actual test experiment format, and the



observance of all the groups in a "dry run" insured that procedures used later would be acceptable. It also served to verify that there was ample time to complete the session and gather resultant data in the scheduled 50 minute periods. All environmental conditions were examined, and the correct positioning of stereo speakers and settings on rheostats was noted to insure equal noise and light at both positions. This also served to insure that the settings could be easily duplicated during the actual sessions.

### 3. Conduct of the Practice Session

The authors had prepared the laboratory before the subjects arrival so that all equipment was turned on, the appropriate NWISS scenario was initialized and placed in pause mode and the voice patterns for the intended VERBEX 3000 user were loaded into the system. A command to save the session was included for post analysis to insure that the desired data was actually being collected.

Before the start of the practice session, the subjects were given an administrative briefing about the practice run, and concerning specific instructions for the test sessions. The exact items covered are shown in Appendix C. Following the administrative briefing, the subjects were briefed on the particular practice scenario. Each individual was supplied with a sample list of NWISS commands to be used for reference during the session, if needed. A verbal briefing on the mission was also given to all subjects, and any questions were answered.



The NWISS game was allowed to run for approximately 30 minutes. At the completion, the subjects departed and, if another group was to come in, the authors prepared the laboratory accordingly. Additionally, copies of the photographed game screens were printed at this time. As was previously mentioned this procedure was only performed for the first few sessions to verify correct information, and to determine how long the entire analysis process would take. Printouts were not necessary for all the practice sessions because the data would not be used in the experiment.

## VI. CONDUCT OF THE EXPERIMENT

### A. INTRODUCTION

This chapter will describe the layout and control of the laboratory, the actual conduct of the experiment and the method used to record the individual sessions.

### B. LABORATORY ENVIRONMENT

#### 1. Configuration

The NWISS Command and Control laboratory was divided into two independent bays (each configured approximately sixteen feet high by eighteen feet in length) and was used to simulate the environment for the experiment. The following equipment for each of the two input modes was selectively located in its respective section:

- 1) a Ramtek graphics screen with a separate stereo speaker beside it for producing background noise,
- 2) a VT100 game status terminal which was used to retrieve game information only, and
- 3) a player terminal (VT102 for the Macintosh or ADM-31 for the voice) which allowed commands to be physically entered into the computer.

Using the ADM-31 as a validation device for character strings enroute to the computer, the voice subjects were able to monitor their inputs, change/cancel incorrect entries and use the keyboard (on isolated occasions) in the event voice recognition proved to be an insurmountable problem. The laboratory's physical layout provided the subjects with easy access to all terminals, and the experiment proctors could evaluate the progress of each session

using the VAX/NWISS control station in the Control Bay. Additional equipment was located in each bay, but was separated by a partition and not directly associated with the experiment itself (see Figure 6.1 for a complete Laboratory Layout).

## 2. Laboratory Control

Personnel traffic was not restricted during the individual voice/Macintosh practice sessions, but during the actual test sessions, access to the laboratory was more restrictive in nature. While the experiment was in progress all personnel were requested to use the rear entrance to preclude the distraction of the pneumatic sliding door, and to prevent undesirable/uncontrolled light from entering the controlled surroundings. Laboratory users not involved in the experiment were advised that use of the facility was defaulted to whatever noise and light environment was currently in use during the experiment. Due primarily to this precautionary measure, the environmental conditions which had been adjusted and measured before each run were adequately preserved.

## C. TEST SESSIONS

The procedure for the actual test sessions was an exact duplication of the practice sessions. As before, prior to the arrival of the subjects, the proper NWISS scenario was initialized and the voice patterns for the subjects scheduled were loaded into the machines (see Appendix B). The subjects were briefed in accordance with Appendix C and provided with a copy of the applicable scenario for their perusal. Any peculiarities within a given

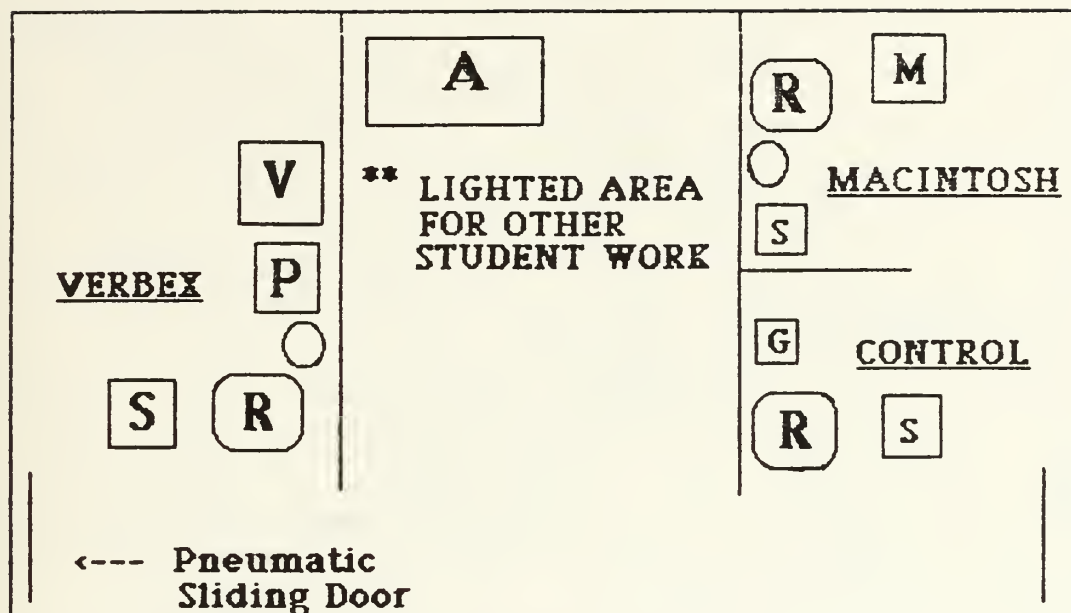


Figure 6.1 Laboratory Configuration

scenario which the subjects would not normally have experienced previously were pointed out, and any questions were answered.

Following the briefing, the actual NWISS session began. After the subjects went to their positions, the proper noise and lighting levels were set, and the game was started. All the sessions were run for forty minutes. Personnel who had repeated difficulties were given assistance as necessary. At the conclusion of each run, copies of the game sessions were printed out and annotated for later classification. The forty minute game time point was noted on the printouts, and the number of commands and "Control\_K's" entered were computed. [Ref. 2]

While the majority of the experiment sessions were completed as planned, some rescheduling was needed due to the absence of personnel, or to some unexpected NWISS game problems. Rescheduling of personnel created no particular problems because each input method was used to play an individual NWISS session, and the proper scenario and environmental conditions could be reset for any individual makeup as required.



## VII. DATA ANALYSIS

### A. INTRODUCTION

The purpose of this experiment was to evaluate the effectiveness of two computer input devices under various environmental conditions. Since a wargame scenario was used, the conditions simulated tactical or Command Information Center (CIC) environments. The hypothesis for the experiment was there would be no significant difference between using the VERBEX 3000, the Macintosh or the keyboard systems. As stated earlier, the results were based on the positive Measure of Effectiveness of comparing the total number of commands entered, and the total number of mistakes made while entering the commands.

### B. DATA SUMMARY

The number of commands entered was determined by summing the "order entered" lines. As previously noted, the only exception was the aircraft launch sequence which was counted as either four or five; depending on whether or not "weapons were loaded". The mistakes were determined by summing the applicable Control\_K's that were correctly and deliberately entered. Raw data for the experiment is listed in Appendix E.

Table 7.1 is the key which describes the environmental conditions used in the experiment. It should be used as a reference when analyzing the other accompanying tables and figures in this chapter.

**TABLE 7.1****ENVIRONMENTAL CONDITIONS****NOISE:**

LOW - 65 Decibels (db)

HIGH - 85 Decibels

**LIGHT:**

NORMAL - 1 Foot-lambert

LOW - .05 Foot-lambert

Table 7.2 summarizes the mean number of commands entered, based on the variable noise/light conditions. Figure 7.1 displays the data in graphic form.

**TABLE 7.2****MEAN NUMBER OF COMMANDS ENTERED****Environmental Condition: Noise/Light**

Input	Low	Std	Low	Std	High	Std	High	Std	
Device	Norm	Dev	Low	Dev	Norm	Dev	Low	Dev	Avg
Verbex	55.3	23.4	69.8	23.4	40.8	15.6	60.7	27.3	56.7
Macintosh	28.2	9.4	43.4	10.0	44.4	16.8	47.2	11.8	40.8
Keyboard	74.1	15.9	71.7	19.6	79.0	27.8	71.5	19.5	74.1

L = Low; H = High; N = Normal

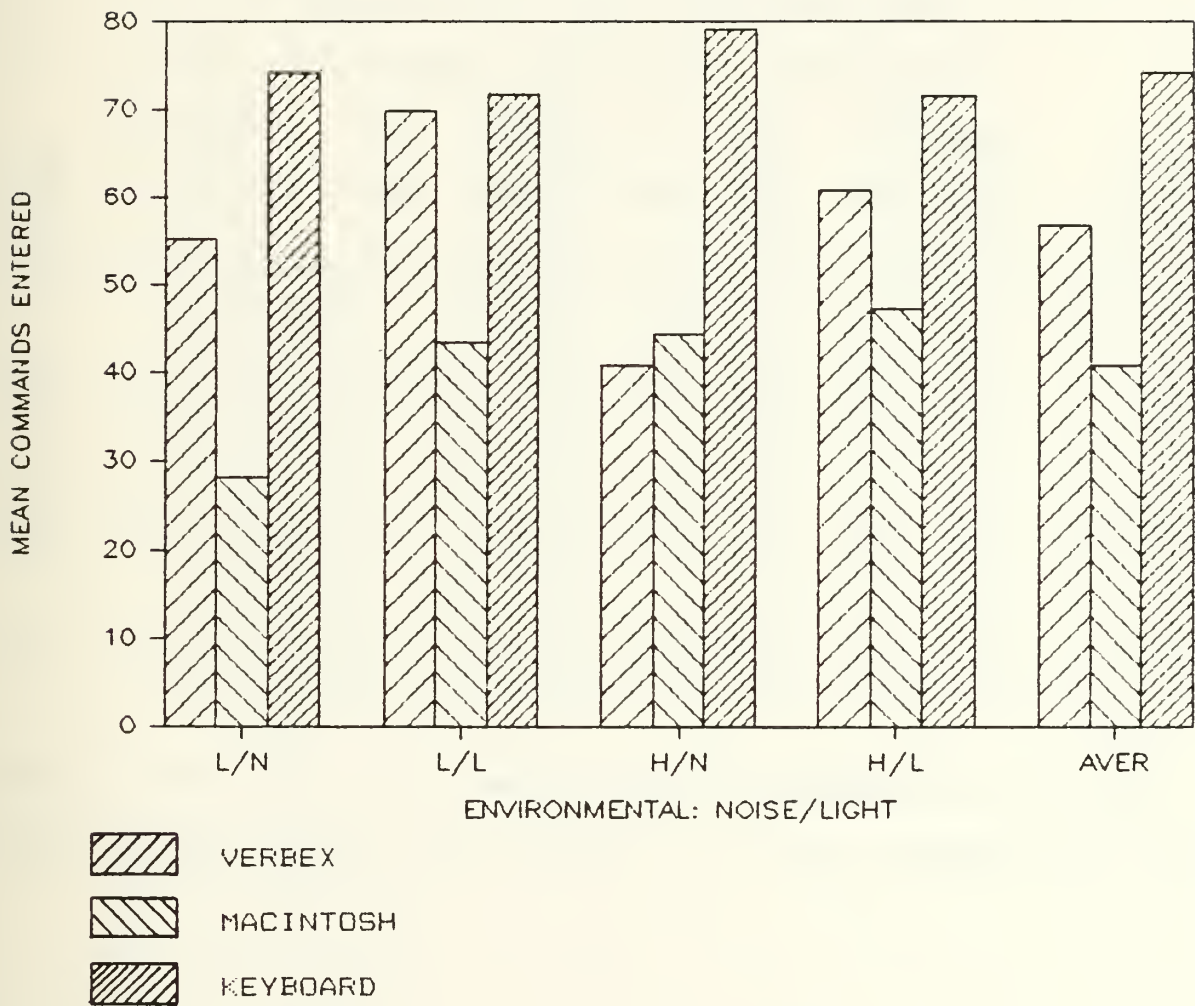


Figure 7.1 Mean Commands Entered vs. Environmental Conditions

Table 7.3 summarizes the Mean Number of Control\_K's entered, based on the variable noise/light conditions. Figure 7.2 displays the data in graphic form.

**TABLE 7.3**

MEAN NUMBER OF CONTROL\_K'S ENTERED

Environmental Condition: Noise/Light

Input	Low	Std	Low	Std	High	Std	High	Std	
Device	Norm	Dev	Low	Dev	Norm	Dev	Low	Dev	Avg
<hr/>									
Verbex	8.3	8.7	4.5	2.3	5.3	3.8	5.3	4.1	5.9
Macintosh	7.8	3.7	5.8	2.4	6.2	3.5	7.8	4.2	6.9
Keyboard	5.6	4.3	7.7	8.0	7.6	3.6	7.3	6.4	7.0

Table 7.4 summarizes the Mean Number of Commands entered based on the trial number. Figure 7.3 displays the data in graphic form.

L = Low; H = High; N = Normal

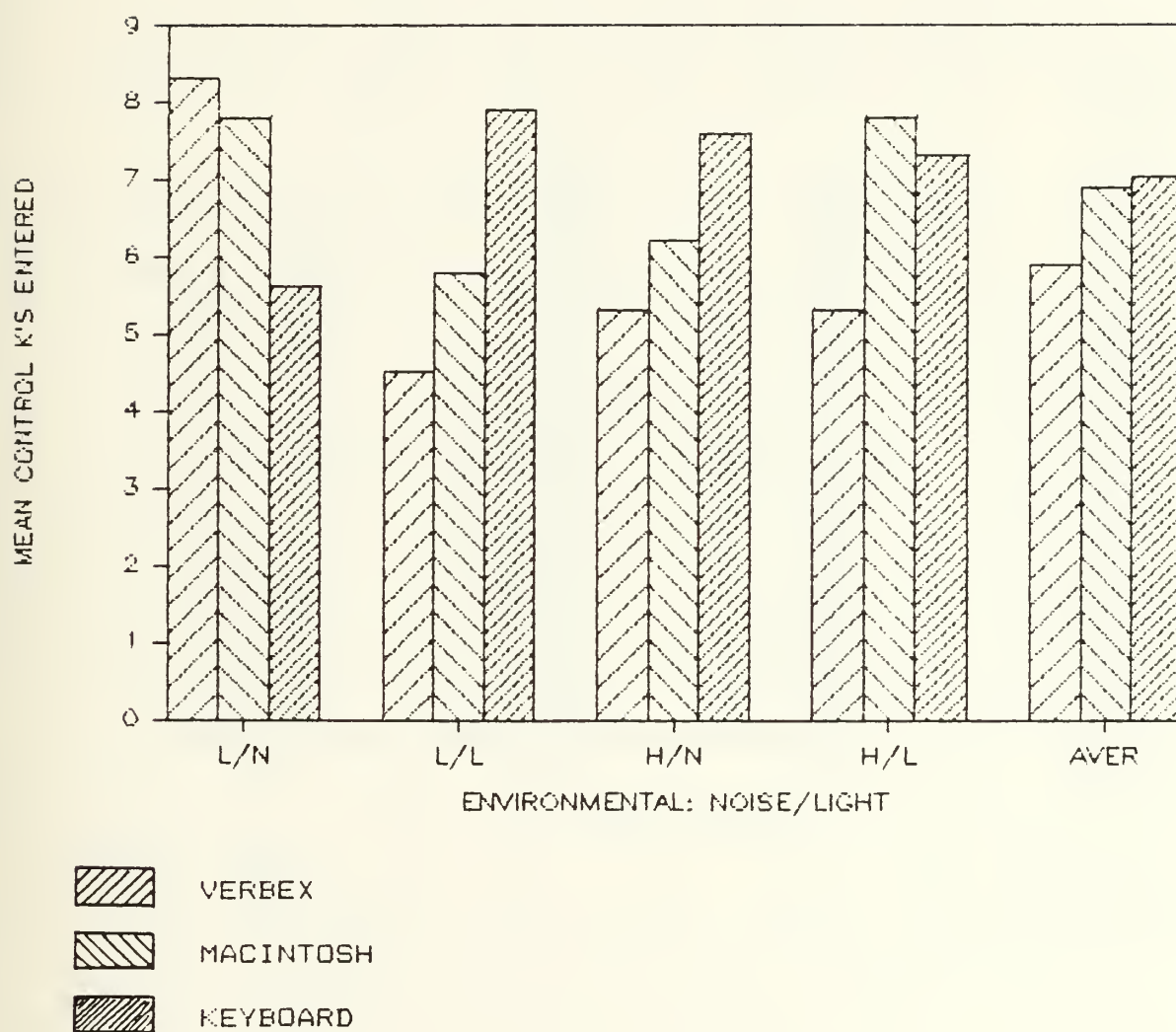


Figure 7.2 Mean Control K's Entered vs. Environmental Conditions



**TABLE 7.4**  
 MEAN NUMBER OF COMMANDS ENTERED  
 TRIAL NUMBERS

Input		Std		Std		Std		Std
Device	1rst	Dev	2nd	Dev	3rd	Dev	4th	Dev
-----	-----	-----	-----	-----	-----	-----	-----	-----
Verbex	60.6	21.1	51.5	19.4	60.1	29.2	55.3	28.4
Macintosh	27.9	9.2	38.6	15.4	47.0	7.6	51.3	12.2
Keyboard	63.7	23.1	76.2	20.3	73.2	16.2	83.2	20.1

Table 7.5 summarizes the Mean Number of Control\_K's entered based on the Trial Number. Figure 7.4 displays the data in graphic form.

**TABLE 7.5**  
 MEAN NUMBER OF CONTROL K'S ENTERED  
 TRIAL NUMBERS

Input		Std		Std		Std		Std
Device	1rst	Dev	2nd	Dev	3rd	Dev	4th	Dev
-----	-----	-----	-----	-----	-----	-----	-----	-----
Verbex	8.7	8.4	6.8	4.1	3.6	2.3	4.5	3.4
Macintosh	7.2	3.7	7.2	3.6	6.9	3.7	6.4	3.4
Keyboard	8.1	5.5	9.0	8.3	6.1	4.3	5.2	3.4

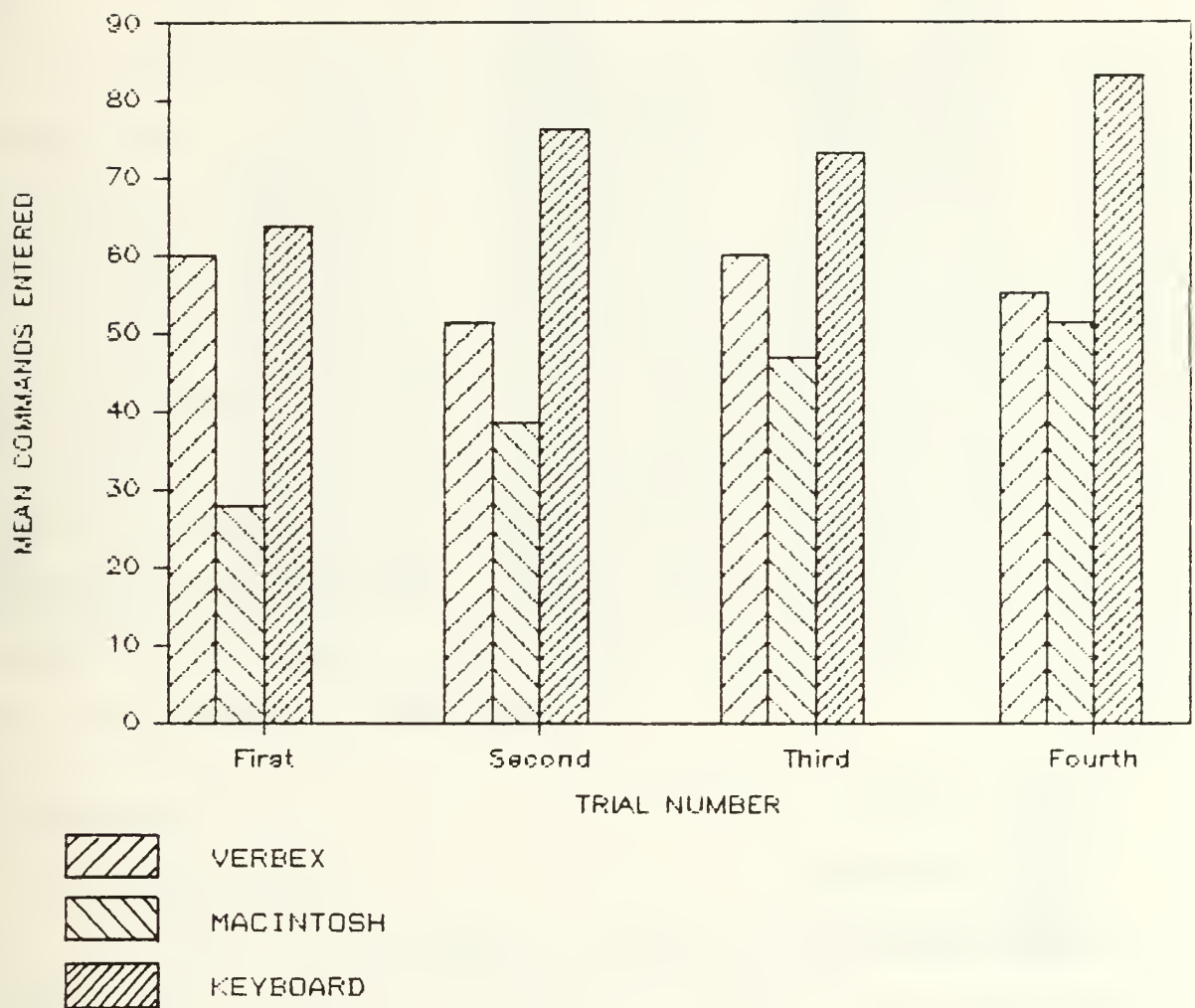


Figure 7.3 Mean Commands Entered vs. Trial Numbers

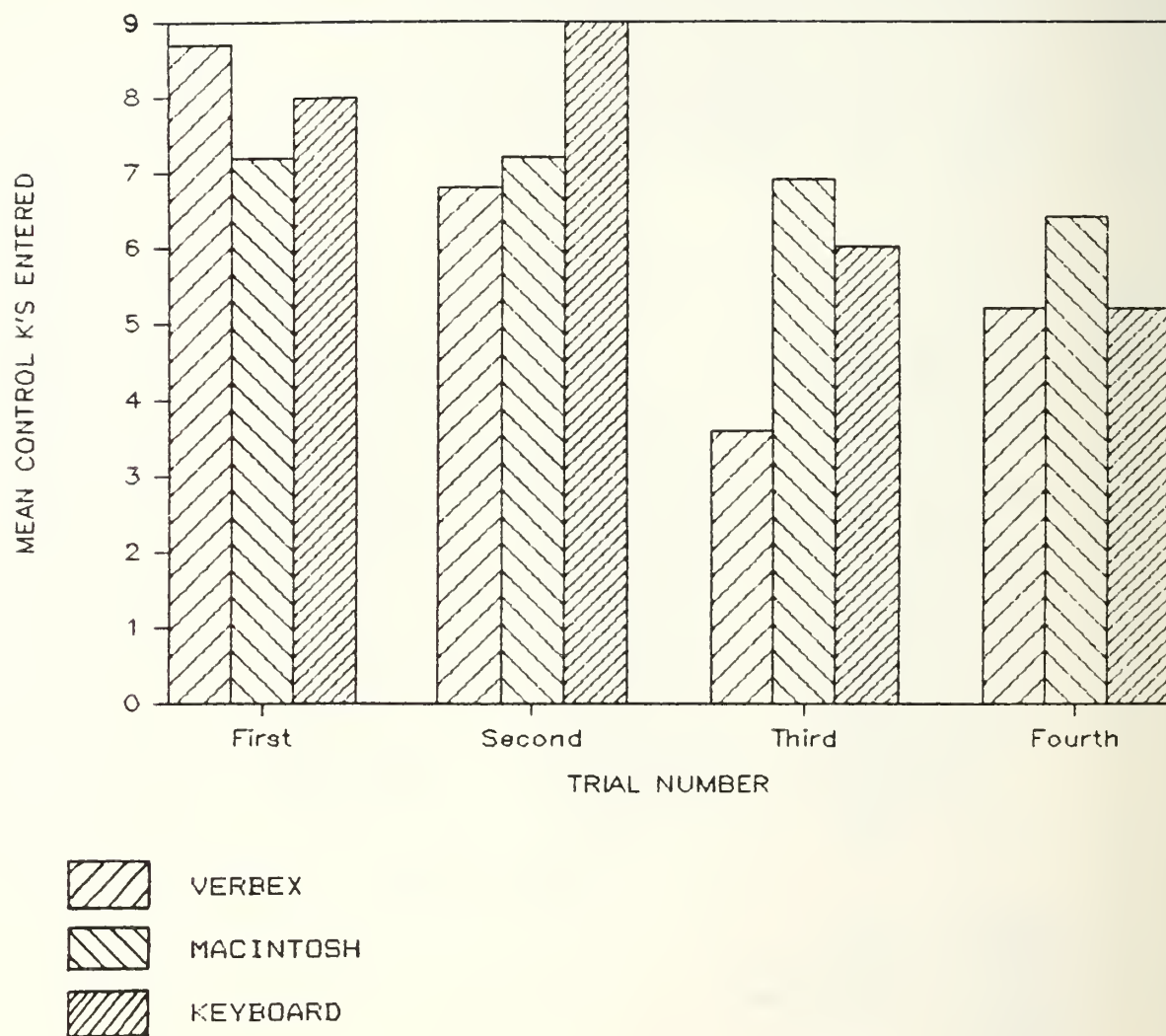


Figure 7.4 Mean Control K's Entered vs. Trial Numbers

## C. STATISTICAL METHODS

Once the data from the experiment was compiled, two-way analysis of variance techniques helped evaluate the results. Two statistical analysis software programs resident in the IBM 3033 mainframe computer were used to facilitate the calculations. The first was MINITAB, and the second was the Statistical Analysis System (SAS).

In testing analysis of variance the following two assumptions must be made: 1) the populations from which the samples came can be approximated closely with normal distributions, and 2) they all have the same variance. [Ref. 20] For each case, the hypothesis was tested at a confidence level of 95 percent. Additionally, for each environmental condition (i.e., noise/light level), a ratio of the number of errors that can be expected per the number of valid commands entered was calculated. This was computed for each of the three input devices. Finally, an analysis using SAS was conducted as a backup for some of the data that was analyzed using the MINITAB program. [Ref. 21]

## D. ANALYSIS

### 1. Introduction

As with the statistical analysis, it is desirable to use as many data samples as possible. Since it was difficult to commit a large number of subjects to the experiment, each of the 24 subjects participated in four separate sessions, thereby totaling 96 samples (VERBEX 3000 and Macintosh). Again, the

keyboard data was that which was compiled from the Wright/Manson experiment.

It was now important to ensure that the scenarios were varied enough to be an "independent session" for the subjects, so that no unfair advantage would occur during a trial run. The two-way analysis of variance was obtained between the number of commands entered and the different scenarios used. Also, a two-way analysis was conducted between the number of Control\_K's entered and the different scenarios used. The result was the same for each, which indicated that neither one exhibited any significant difference. It is therefore reasonable to assume that the experiment consisted of 96 **individual** sessions. The Wright/Manson experiment consisted of 13 keyboard operators who also played the identical set of 4 different scenarios (totalling 52). The combined total is then 148 sessions (samples) for this experiment.

## 2. Best Environment for Each Input Method

It was expected that each input device would do better under a specific combination of environmental conditions. For two of three devices the results also showed that the combination that provided the greatest number of valid commands to be entered, also provided the fewest number of errors (i.e., Control\_K's). This is a desired situation and is reasonably intuitive. What follows is a brief description of the best environment found for each particular input method. See Figure 7.5 for a listing of the ratios (errors per valid commands) for each device.



	VERBEX	MACINTOSH	KEYBOARD
LOW/ NORMAL	.151	.266	.075
LOW/ LOW	.065	.134	.107
HIGH/ NORMAL	.145	.158	.096
HIGH/ LOW	.098	.159	.102

Figure 7.5      Ratio of Expected Errors Per Valid Command Under the Environmental Conditions Specified

For the VERBEX 3000 system the greatest number of valid commands were entered under a low noise, low light condition. Concurrently, the fewest errors were entered under those exact conditions. Based on the F ratios calculated after performing a two-way analysis of variance (at the 95 percent level), there was **NO** significant difference between the number of commands entered and the environmental conditions. The same result was realized (**NO** significant difference) between the number of Control\_K's (errors inputed) and the environmental conditions. That is, although there is a "lowest ratio" for the VERBEX 3000 system, there is **NO** significant difference between the number of commands entered or errors entered, and the environmental conditions under which it was used. As expected, the lowest ratio (errors per valid command entries) came under the same low noise, low light condition. (See Appendix E for actual Statistical Data.)

For the keyboard system, the highest number of valid commands were entered under two conditions: 1) low noise and normal lighting, and 2) low noise and low lighting. Here again, the fewest number of errors were made under low noise and normal lighting conditions. Like the VERBEX 3000, the F ratio calculated from the two-way analysis of variance revealed **NO** significant difference between the number of commands entered (and the number of Control\_K's entered) and the environmental condition. Nevertheless, the lowest ratio occurred under a low noise, normal lighting condition.

For the Macintosh, the highest number of valid commands were entered under high noise, low lighting conditions. The fewest number of errors were entered under low noise, low light conditions. As with the previous input devices, **NO** significant difference was revealed between the number of commands entered (or the number of errors entered) and the environmental condition used. Here, the lowest ratio occurred while operating under low noise and low lighting conditions.

### 3. Best Input Method for Each Environment

This question was answered using a two-way analysis of variance. Each environmental condition (i.e., noise/light) should reveal a desired input device which yields the largest number of commands, and also the fewest number of errors. As in the previous question, the ratio of errors to valid commands also revealed some practical insight into which device may be preferable when using a particular noise/light condition. The two hypotheses stated that the number of commands entered (and the number of Control\_K's committed) would be equal for all three input devices.

Conclusive results (based on the F ratio at 95 percent) show there **IS** a significant difference between the number of commands entered and the input devices. In all four noise/light conditions the keyboard operators entered more commands than all the other subjects. This was not the case, however, when a measurement of the number of Control\_K's committed was taken. Here, the two-way analysis of variance revealed no significant difference among any noise/light condition and the input devices. Even on

examining the raw data it was shown that **NO** clear advantage existed for any particular device. The calculated ratios (see Figure 7.5) displayed the following advantages under each environmental condition:

#### BEST INPUT METHOD

- |                                    |          |
|------------------------------------|----------|
| 1. Low Noise / Normal Light -----  | KEYBOARD |
| 2. Low Noise / Low Light -----     | VERBEX   |
| 3. High Noise / Normal Light ----- | KEYBOARD |
| 4. High Noise / Low Light -----    | VERBEX   |

#### 4. Best Overall Input Method

This question was answered using a one-way analysis of variance. The F ratio was again calculated at a 95 percent confidence interval, and the hypotheses were the same as the ones described in the previous question.

The results revealed a significant difference between the mean number of commands entered and the input devices, thereby rejecting the null hypothesis. The raw data showed that the keyboard operators entered more commands than the operators of the other devices. The VERBEX 3000 players were only slightly lower, while the Macintosh players entered an average of 43 percent fewer commands per session.

As far as the number of errors committed was concerned, the one-way analysis of variance showed **NO** significant difference; thereby accepting the null hypothesis that the number of Control\_K's

entered by all three input devices was equal. The raw data showed only a difference of 2 or 3 errors amongst input devices per each session. The VERBEX 3000 had the fewest (an average of 5.8), next was the Macintosh (with 6.9), and finally the keyboard (with 8.1).

#### 5. Possible Learning Curves

It was interesting to note that **NO** significant learning curve took place between the subjects when considering either the number of commands entered, or the number of Control\_K's committed. It is worth mentioning, however, that the Macintosh subjects increased the number of commands entered for each succeeding trial (session). This can be seen graphically depicted in Figure 7.3. The reverse was not the same for the number of Control\_K's that the subjects entered, and again, neither was it significant (this can be seen graphically in Figure 7.4).

#### **E. SUMMARY**

To summarize, there were few significant results. Even with the added benefit of looking at the raw data, not all the questions were answered unequivocally. None of the three input devices could be labeled as a clear-cut winner over any of the other devices. Each of the devices performed best given a specific set of environmental conditions. Oddly enough, the VERBEX 3000 and Macintosh both performed best in the Low Noise/Low Light conditions, and the keyboard performed the best in the High Noise/Normal Light conditions. Without regard to the Noise/Light conditions, the VERBEX 3000 system had the lowest ratio (i.e., error to command), with the keyboard a close second (.102 to .112 respectively). The



Macintosh entered fewer commands than the others, and was ranked second when measuring the numbers of errors committed. Additionally, no significant learning took place during the four separate sessions that each individual participated in during the experiment.

## VIII. CONCLUSIONS AND RECOMMENDATIONS

### A. INTRODUCTION

The objective of this thesis was to evaluate different input interfaces to the NWISS wargaming scenarios resident on the VAX 11/780 computer. The two hypotheses were that the mean number of commands entered and the mean number of errors committed (using any of the three tested input devices) would be equivalent. While the objectives of the thesis were successfully established on the completion of the experiment, **no** single input device can be designated as the "better" of the three.

### B. CONCLUSIONS

Before the experiment, the authors of this thesis anticipated that the voice system would outperform the other devices. By the term "outperform", it is meant that the VERBEX 3000 subjects would enter significantly more commands and commit fewer overall errors than the other devices. It was expected that the Macintosh would outperform the keyboard simply by virtue of its current technology. In general, the analysis of the data did not confirm these expected outcomes.

Many reasons can be given to explain these unexpected results. As far as the keyboard was concerned, most of the subjects wasted little time in moving their keyboards as close as possible to their data input (CRT) screen in the low light condition. Using the video screens inherent glow helped considerably in locating the correct keys; especially for the non-typists. Also, a post

experiment survey revealed that the keyboard operators were experienced typists by and large. By this it is meant that at worst most of the subjects were able to use both hands while only occasionally looking at the keys. By implication, military officer postgraduate students are collectively more likely to have had typing experience (i.e., used typing skills during their lengthy education/training) than the general population. Their average lifetime exposure to keyboard technology is high, and again this particular group was above the norm. [Ref. 2] On the other hand, none of the subjects had prior experience with either the continuous voice system, and only a few subjects had prior experience with the Macintosh microcomputer system. This brings into focus the implications of the necessary training involved for each device. The VERBEX 3000 subjects trained with the voice system an average of six hours only one week before the experiment. Considering that it takes years of frequent typing to become proficient, the VERBEX 3000 subjects did well to keep up with the keyboard operators. The Macintosh subjects practiced for about 35 minutes each, concentrating totally on developing the motor skills necessary to maneuver the arrow using the mouse peripheral. In retrospect, it is felt that they would have performed considerably better if they had been as proficient (through additional training) in the use of the mouse as the keyboard subjects were in using their acquired typing skills. The raw data from the Macintosh players showed a slight increase in the mean number of commands entered for each individuals' succeeding trial. Although it was not a

significant increase, the same statement could not be made for the other devices.

When looking at the ratios (see Figure 7.5), each device performed well under certain noise/light conditions. The VERBEX 3000 and the Macintosh had the lowest error to command ratio under the low noise/low light conditions. Not surprisingly, the keyboard operators had the lowest ratio under the high noise/normal light conditions. For the keyboard and VERBEX operators, each had the lowest error to command ratio in two of the four environmental conditions. Looking specifically at the "light conditions" (without regard to noise), the VERBEX 3000 system had a lower ratio than the other devices. Similarly, the keyboard users attained their lowest ratio under "normal light conditions". Considering the inexperience of the VERBEX 3000 operators, they did extremely well in the most likely high stress, wartime environment (high noise, low light). The error to command ratio was .015 lower than the second best, keyboard.

Although we can logically conclude that the keyboard did perform better than the other devices, it would be illogical to conclude that the other input devices do not warrant further research. Just looking specifically at noise conditions (without regard to the lights) the VERBEX 3000 system had a lower ratio than the other devices. Considering the inexperience of the VERBEX 3000 operators, their ratio was only .004 higher than the keyboard subjects in the most likely high stress wartime environment (that of high noise and low light conditions).

Another area analyzed was the presence of any learning trends the subjects may have received from previous sessions. None of the subjects performed significantly better over the four trials. While this was not necessarily an encouraging trend, this result supports the independence of each session, thereby making the sample size of the experiment itself more valid.

One final comment should be made about the likelihood that inexperienced operators will often be at the controls of the input media in an academic or training environment. For example, a senior officer (i.e., O-5 or above) attending the Naval War College will play similar war games. It is highly unlikely that an individual will have had prior experience using speech or "menu-oriented" systems for input communication. It can therefore be concluded that with a minimum of introduction to these devices, almost equal performance can be attained to that of the experienced typist if the syntax required of the game commands is also well learned by the novice user.

### C. RECOMMENDATIONS

It is the opinion of the authors that further study is justified concerning the potential of the three input devices. Before another experiment is performed, however, it is recommended that sufficient training of the subjects be conducted. It was felt that the Macintosh subjects would have performed significantly better with more extensive training and dedicated practice sessions. This would have enabled them to become more familiar with the coordination required to effectively maneuver the cursor with the



mouse. The problem with this proposal is the time constraint imposed on both the planning and execution of the experiment. Optimally, all subjects should be equally skilled in the use of the particular input device.

Additionally, the software interface program for the Macintosh should be modified to facilitate a quick, efficient and accurate mode of input for the user. This modification would require a more natural arrangement of commands to allow an easier interaction with the sequence of these commands required by the syntax design of the software.

Acquisition costs for these devices and any study of cost/benefit relationships would provide additional fertile ground for future research. Current downward trends in hardware costs, and a general lowering of costs for all technologies which are driven by micro-computer advances in the marketplace, cause a "concept of costs" for these systems to be well worth consideration.

NWISS should be used as a medium for any further experimentation. The necessary peripherals are all established, and it provides an accurate simulation of a real-time environment. Varying environmental conditions are easily simulated in the C3 laboratory, and the accessibility limitation makes it an ideal place to conduct further experiments.

In conclusion, future experiments should include the previously suggested modification to the Macintosh software and the most advanced "touch screen" and voice technology available. It is felt that these three devices have the greatest potential to meet the requirements for an efficient input medium.

#### D. SUMMARY

Man's zeal to accomplish the ideal "man-machine" interaction has allowed significant progress to occur regarding input devices. The keyboard was first, and has been dependable but restrictive; sometimes to the point of being inconvenient. Quick to approach popularity were several "non-traditional" methods; one being the voice system. The discrete voice system is unnatural and hard to use for most users, while the continuous system is easier to use and more convenient for the jobs requiring user input and manual labor simultaneously. Two other methods are the "pull-down" menu and the "touch screen" technologies. Both have been successful even in their early stages of development.

Man is quickly approaching the doorstep of Fifth Generation computer technology. Therein lie "intelligent systems" which will give increasing flexibility to input devices of the future. Unfortunately, there can be no "perfect" universal input method due primarily to the varied requirements and restrictions innate to each individual job. Nevertheless, it follows that continued research should be aimed at producing a body of knowledge which would allow us to pick the best method of computer interaction in a specific environment. Although it is recognized that computer speeds today are restricted from full use because of the slowness of interface hardware, the rate of progress in developing high speed CPUs is compounding the problem. Therein lies the impetus to continue toward the development of better input media.

## APPENDIX A

### SCENARIO BRIEFINGS

#### SCENARIO A

**SITUATION:** Hostilities have already been declared, and Orange forces are providing escort for a large convoy of cargo ships carrying nuclear/chemical weapons.

**FRIENDLY FORCES:** You have available one Aircraft Carrier, 2 Knox class destroyers, a Los Angeles class submarine (positioned north of the convoy) and 2 flights of 4 P3C aircraft.

**ENEMY FORCES:** Orange forces have 8 ships escorting 10 merchant ships in the convoy. No air assets are presently available, or expected.

**MISSION:** Destroy all Orange combatants without inflicting damage to any cargo vessels (due to the nature of their cargo).

**MOE:** POSITIVE

-- number of weapons fired during the session

-- number of combatants identified, hit and damaged/sunk

NEGATIVE

-- number of merchant ships hit/sunk

-- number of Blue Aircraft lost

-- number of Blue vessels hit/sunk

## SCENARIO B

SITUATION: Approximately 20 Orange merchant vessels are anchored in port waiting to unload various cargo. Hostilities are imminent.

FRIENDLY FORCES: Blue forces include 2 P3C aircraft and two groups of 5 A6E's. An aircraft carrier is available to supply further air assets if deemed necessary.

ENEMY FORCES: Location and makeup of Orange forces is undetermined due to poor weather/intelligence.

MISSION: Destroy as many merchant ships as possible, and attack combatants only if fired upon.

MOE: POSITIVE

- number of weapons fired
- number of merchant ships identified, hit and damaged
- number of combatants identified, hit and damaged

## NEGATIVE

- number of Blue forces damaged/lost
- number of merchant ships remaining

## SCENARIO C

SITUATION: There are confirmed reports that large numbers of Orange Combatant units have left port, are running EMCON silent and are unlocatable at this time. There are friendly/neutral forces in the neighboring area and tension is rising. No hostilities have been declared as yet.

FRIENDLY FORCES: 1 P3C aircraft and 4 F14A aircraft are available. Other assets are in the area, but are not under your direct control. Any merchant ships encountered are not to be considered hostile.

MISSION: Search for possible contacts in the area from 35N to 42N, and from 174E to 180E (or 164E to 170E depending on the oceanic displacement). Locate, identify and designate as many vessels as possible as either enemy, friendly or neutral. Center the plot upon the P3C at the start of the session, and weapons will remain tight unless fired upon.

MOE: POSITIVE

- number of Orange forces properly identified
- number of Blue forces properly identified
- number of Neutral forces properly identified

NEGATIVE

- number of forces improperly designated
- number of forces remaining not found/properly designated



## SCENARIO D

SITUATION: An Orange SAG is 100 NM directly north of your position and you are tasked to intercept and visually identify it. Hostilities have not been declared as yet, but are expected to break out soon.

FRIENDLY FORCES: One Aircraft Carrier (with its associated aircraft), 3 escort ships and a submarine.

ENEMY FORCES: The strength of the Orange forces is unknown, but they are not expected to have any aircraft launched at this time.

MISSION: Launch carrier based assets to search/identify the suspected Orange SAG. All weapons will remain tight unless fired upon.

MOE: POSITIVE

- number of aircraft successfully launched
- number of enemy assets properly identified
- number of enemy assets damaged (only if fired upon)

NEGATIVE

- number of Orange forces not designated as enemy
- number of Blue ships hit/lost
- number of Blue aircraft lost

# APPENDIX B

## EXPERIMENT TEAM MEMBERSHIP/SCHEDULE

Team	Verbex	Macintosh
1	Findlay	Caldwell
2	Gahagan	Roberts
3	Prautzsch	Stone
4	Orcutt	Wicks
5	Goyden	Alecxiu
6	Herkert	Moreau
7	Kotowski	Kennedy
8	Cogliandro	McLaughlin
9	Thompson	Tekel
10	Buettner	Schuh
11	Hill	Wall
12	Ocain	Gruetzner

## EXPERIMENT SCHEDULE

Time Date	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600
15 OCT						1A1	2B1	1D3	2A4	
16 OCT	3B1	7D2	7A3	5D1		3A2				
17 OCT	5B3		3D4			5A4		3C3	1B2	1C4
18 OCT		6A1	2D2	6D3				5C2		
21 OCT	8D2	2C3					4D1	4C2	4B3	4A4
22 OCT						7C1	8C1	7B4	9D1	9A3
23 OCT				8A3		8B4	6B2	9C2	6D4	
24 OCT		11B1		9B4		11C4	10C1	10D3		
25 OCT		11A2			11D3		10A2	12A1	12B3	12C4
28 OCT			12D2				10B4			

## APPENDIX C

### SUBJECT ADMINISTRATIVE BRIEFING

**NOTE:** The following administrative briefing was initially given to each subject prior to the beginning of the experiment. Key points were re-emphasized at each session as applicable.

1. The sessions would be approximately 50 minutes in length, each subject would be scheduled for four individual sessions and a master schedule of all sessions was posted on CDR. Stewart's office door for reference, and to facilitate changes throughout the experiment.
2. Subjects were asked to wait outside the laboratory until told to enter. This precaution was taken in order to preclude an inadvertent disturbance in the environment if a previous group session was still in progress.
3. The voice patterns for the scheduled VERBEX 3000 subject were already loaded to avoid any unnecessary delay. The user simply had to set the gain in order to be ready to start the session.
4. The noise/light conditions for the particular session were explained and set.
5. The subject was provided with the scenario for the session and all key points were verbally emphasized.
6. All subjects were advised to ask for help during the session if any problems were encountered.
7. The subjects were asked not to discuss any of the scenarios following their sessions until the experiment was completed.
8. Each group was reminded of their next scheduled laboratory period following the completion of a session.

## APPENDIX D

### EXAMPLES OF COMMAND SEQUENCES

- "Display ... Radius 2 5 0"
- "Execute BAIRASW"
- "Execute F14STRCAP"
- "For Kitty ... Launch ... 2 A7E A6E ...(course) 2 3 5...(speed)  
4 3 0 ... (altitude) 1 5 0 0"
  - Flt. Plan: "Mission Strike"
  - Flt. Plan: "Proceed position ... 4 5 N ... 1 1 5 - 2 0 E"
  - Flt. Plan: "Load ... (equipment) 3 Shrik ... 6 MK82"
  - Flt. Plan: "Stop"
- "Designate Enemy ... (track) E E 0 0 5"
- "Display ... Place Circle Force ... M P 6 1 5 (radius) 5 0 "
- "For V A 0 1 0 ...Weapons Free Enemy All"
- "For S H 2 0 0 ... Barrier ...(position) 1 5 - 2 0 N ... 1 2 5  
- 1 5 E ... (bearing) 1 3 5 ... (distance) 4 5 ... (using)  
S S Q 6 2 ... (spacing) 4"

**NOTE:** Words in (parenthesis) are prompts that appear on the speech unit.

## APPENDIX E

INDIVIDUAL DATA

## Environmental Condition

1 = Low Noise, Normal Light; 2 = Low Noise, Low Light  
 3 = High Noise, Normal Light; 4 = High Noise, Low Light

<u>Team</u>	<u>Input Device</u>	<u>Scenario</u>	<u>Env Condition</u>	<u>Cnds</u>	<u>Control K</u>	<u>Trial #</u>
1	Verbex	A	1	80	6	1
		B	2	78	7	2
		C	4	63	11	3
		D	3	98	8	4
	Macintosh	A	1	27	7	1
		B	2	56	11	2
		C	4	26	4	3
		D	3	38	9	4
2	Verbex	A	4	85	16	1
		B	1	78	34	2
		C	2	75	3	3
		D	3	27	1	4
	Macintosh	A	2	52	8	3
		B	4	56	2	4
		C	3	35	6	2
		D	1	38	11	1
3	Verbex	A	2	64	9	1
		B	1	67	10	2
		C	3	36	12	3
		D	4	36	5	4
	Macintosh	A	2	37	5	1
		B	1	28	13	2
		C	3	56	11	3
		D	4	49	13	4
4	Verbex	A	4	42	7	4
		B	3	44	1	3
		C	2	62	3	2
		D	1	51	4	1
	Macintosh	A	4	71	7	4
		B	3	54	3	3
		C	2	37	7	2
		D	1	24	5	1



# APPENDIX E (cont.)

<u>Team</u>	<u>Input Device</u>	<u>Scenario</u>	<u>Env Condition</u>	<u>Cnds</u>	<u>Control K</u>	<u>Trial #</u>
5	Verbex	A	4	7	3	3
		B	3	18	2	1
		C	2	73	5	4
		D	1	39	4	2
	Macintosh	A	4	37	6	3
		B	3	22	14	1
		C	2	29	6	4
		D	1	17	8	2
6	Verbex	A	1	33	8	1
		B	2	112	6	3
		C	4	60	1	2
		D	3	45	3	4
	Macintosh	A	1	27	10	1
		B	2	43	6	3
		C	4	50	5	2
		D	3	42	9	4
7	Verbex	A	3	19	10	1
		B	4	67	1	4
		C	2	81	4	3
		D	1	95	6	2
	Macintosh	A	3	33	4	1
		B	4	45	4	4
		C	2	39	2	3
		D	1	35	6	2
8	Verbex	A	3	40	5	4
		B	2	27	6	3
		C	4	47	5	2
		D	1	37	12	1
	Macintosh	A	3	39	5	4
		B	2	44	6	3
		C	4	32	12	2
		D	1	8	2	1
9	Verbex	A	3	48	4	2
		B	1	48	2	4
		C	2	49	3	3
		D	4	50	3	1
	Macintosh	A	3	44	4	2
		B	1	49	2	4
		C	2	38	3	3
		D	4	27	5	1

## APPENDIX E (cont.)

<u>Team</u>	<u>Input Device</u>	<u>Scenario</u>	<u>Env Condition</u>	<u>Cmds</u>	<u>Control K</u>	<u>Trial #</u>
10	Verbex	A	2	45	0	3
		E	4	81	4	4
		C	1	41	5	1
		D	3	68	6	2
	Macintosh	A	2	46	7	3
		B	4	61	14	4
		C	1	27	10	1
		D	3	29	6	2
11	Verbex	A	2	69	4	4
		E	1	17	1	1
		C	4	57	6	2
		D	3	39	3	3
	Macintosh	A	2	35	5	4
		B	1	29	6	1
		C	4	40	3	2
		D	3	49	5	3
12	Verbex	A	1	75	8	1
		B	3	42	6	2
		C	4	100	6	3
		D	2	102	4	4
	Macintosh	A	1	41	13	1
		B	3	83	7	2
		C	4	59	13	3
		D	2	65	4	4

## APPENDIX F

### NWISS/VERBEX 3000 USERS GUIDE

#### INTRODUCTION:

This users guide was prepared to facilitate cognizant individuals in training their individual speech patterns to the Verbex 3000 voice terminal. The unit has a maximum vocabulary capacity for 360 words/utterances, 150 of which will be trained in order to interface wargaming scenarios resident on the VAX 11/780 computer.

The guide is divided into the two (2) separate sections that are representative of each actual phase of training. The first phase is ENROLLMENT, which allows each word/utterance to be individually and repeatedly spoken. The second phase is TRAINING, which incorporates the repeated use of the phraseology necessary for wargame scenario interaction.

What follows is a list of specific procedures used to enable the sytem for both the ENROLLMENT and TRAINING phases of the voice experiment:

1. The machines (Verbex, ADM 31, VT-102, and the speech unit) are connected using the proper adapter as shown in Figure #1. (Figure #2 shows the configuration to run NWISS on the VERBEX 3000). The small machine to the right of the VT-102 has "VERBEX 3000" printed on the top, and will hereafter be referred to as the "Speech Unit", so as to not be confused with the large VERBEX 3000 unit located just to the left of the table. The following specific procedures should be utilized to effect proper set-up:
  - A. Turn the ADM 31, VERBEX, and VT-102 to the power-on position (see Figure #1). NOTE: Turning the ADM 31 on is optional for both phases.
  - B. The VT-102 and the speech unit will automatically run through a self-test (using the alphabet). Upon completion of this procedure, the speech unit will read: " Booting VERBEX 3000 ". NOTE: The VT-102 screen will be a scrambled/garbled alphabet on occasion; this is still considered to be normal operation and will not effect the follow-on VERBEX enrollment/training phases.

- C. Now complete the following steps to enable the system:
1. Press the SET-UP key on the VT-102.
  2. Press the Set Up A/B (#5) key --- to set-up "B".
  3. Press the Transmit Speed (#7) key --- press slowly and repeatedly to scroll to 4800.
  4. Press the Receive Speed (#8) key --- press slowly and repeatedly to scroll to 4800.
  5. Press the SET-UP key to exit.
- D. Hit the RETURN KEY (of VT-102) --- this will move the cursor to the left side of the screen.
- E. With the cursor on the left side of the (VT-102) screen enter the following commands sequentially, and wait for the computer to respond (as shown in the output column) between entries:

**ENTER**

**OUTPUT**

dir <return>	directory listing
ed .asd	to use the edit .asd file
n	to number lines
l,\$p	to print lines

- F. If NWISS :w:/NWISS is on line 1: Enter " x ", and continue with step letter I.
- G. If NWISS :w:/NWISS is not on line 1, enter:
1. 2m0 (assuming it is on line two)
  2. l,\$p
  3. x ( this saves the new order )
- H. The prompt on the VT-102 should be " - " (a dash).

I. With a " - " as a prompt, enter: nwiss/nwiss

J. The screen should read:

Monitor: Version 2.0

Copyright (c) 1983, Exxon Corp.

Galcon 3.3 - Grasp 3.1

and the speech unit will read: " Enter user ID = ".

2. From the speech unit enter " 00 ", then press the enter key. This will open the supervisor mode. (**NOTE:** the Enter Key must be pressed after each entry from the key pad on the speech unit). If you realize you have selected an incorrect number for input prior to pressing " ENTER ", you may press " CLR " (the bottom right key on the VERBEX keyboard) and then press the correct number to be reentered. The " Please Wait " light will illuminate, and after a minute or two the speech unit will read: "Add New User?".

3. You will now begin to scroll through Menu #1 (see Menu Listings). Press the NO button to scroll through the Menu for familiarization purposes.

4. To begin the ENROLLMENT phase (approx. 20 min.) Press YES when the menu reads "Add New User?".

5. The speech unit will now read "Enter New User ID =". Enter your user number and press ENTER. **NOTE:** Be sure **not** to enter a number already on the enclosed list of used numbers.(see MENU GUIDE).

6. Put the Headset on with the Mike on the left side (see Figure # 3). MIKE POSITION IS CRITICAL !! Position the Mike only a little to the left of center, and slightly lower than the center of the mouth. It should be no more than 1/2 inch (i.e. about one thumbwidth) from the lips without touching them. Periodically check the microphone for proper placement in order to insure consistency.

7. When the microphone is in place and you are ready, start the amplifier and the tape deck in Bay #2 (in order to interject crowd noise at 65 db into the training), using instructions attached to the tape deck itself.

8. The speech unit will prompt you to "SET the GAIN". It will read "Gain Now at 1, Yes to Set Gain".

(**NOTE:** A gain of 1-3 is OK -- under normal voice levels, a gain of 2 - 3 will be maintained ).



9. When ready to proceed, press the YES button and perform the following steps:

- A. Follow prompt (ie. say "One, two, three, four, testing").
- E. The speech unit will now read: "Gain is set to (1-4), YES to set gain".
- C. Press the YES button.
- D. Follow the prompts as before.
- E. The speech unit will now read: "Gain is set to 3, YES to set gain".
- F. Press the YES button.
- G. Eventually the speech unit will read: "YES to sample background noise".
- H. Press the YES button.
- I. The speech unit will now read: "Remain Silent". At this point do not make any additional noise other than normal breathing (lasts about 2-3 seconds).
- J. The speech unit will read: "Yes to sample silence".
- K. Press the YES button.
- L. The speech unit will now read: "Remain Silent". Again, do not make any additional noise while it is sampling the silence of the environment.
- M. The speech unit will now read: "Gain = (1-4). YES to proceed".

10. **NOTE:**

- A. If the gain is 1-3, do not press YES until you are ready to proceed with the exercise. Be aware that the STOP button can be used at anytime throughout the training cycle for one of three (3) possible reasons:
  - 1. If you would just like to take a break for a few minutes, press the STOP button and you will be prompted to "Continue Training?". Simply press YES when you are ready to continue.

2. If you have made a mistake on an utterance, press the STOP button. Use the NO button to scroll through the menu (#2) until you read "Reject Last Utterance?". Pressing the YES button will accept that command and immediately continue with the next word or phrase.
3. If you feel what you have done is completely unsalvageable to this point, press STOP. Scroll through the menu (#2) until you read "Logout?". Press YES, and if you are in the ENROLLMENT phase, continue with Step #2. If you are in the TRAINING phase, continue with Step # 13 a.

**NOTE:**

Get comfortable before you start. Take breaks if you need them, and strive to be consistent with your voice modulation. See Enclosure # 1 for a complete list of the words you will see throughout the session. The words will be in order of appearance, and the "less than obvious" annunciations will be annotated for standardization purposes.

If the gain = 4, it is best to start again. One way to do this is to continue as normal until the actual cycle has started prompting you with the first word of the session. At this point press the STOP button and scroll through the menu until you read "Logout?". Press YES. The speech unit will read: "Exit (your ID #)", and will then read: "Logout supervisor", followed by: "Enter User ID". Continue from Step #2 using your same initial ID number when responding to the "Add New User?" prompt.

11. Upon completion of the enrollment phase you will see "Enrollment Done. YES to Save". Push the YES button and wait for the "Patterns Saved. YES to Train" prompt to appear. Now push the following buttons in the sequence below:

- A. Push the STOP button.
- B. "Resume Enrollment?"; press the NO button.
- C. "Reject Last Utterance?"; press the NO button.
- D. "Save Patterns?"; press the NO button.
- E. "Logout?"; press the YES button.

12. This concludes the ENROLLMENT phase of the individual voice training cycle.

13. The next phase is TRAINING and it includes ten (10) different sections. You will be asked to train different combinations of the words you used in the ENROLLMENT phase. The names and approximate "time to complete" are listed below:

A. NWISEGRAM1	:	38 min.	6. FIRE	:	17 min.
B. FORCE	:	27 min	7. SHIPORDER	:	24 min.
C. DISPLAY	:	13 min	8. AIRORDER	:	31 min.
D. POSITION	:	6 min.	9. DIGITS	:	9 min.
E. TRACK	:	7 min.	10. LAUNCH	:	32 min.

**NOTE:** You may do these in any order.

The following procedures should be adhered to for each section of the TRAINING phase:

- A. When the speech unit reads: "Enter user ID", you will enter: "00". This procedure logs on the "supervisor".
- B. The speech unit will then read "Add New User?" (as part of menu #1).
- C. Scroll through the menu with the NO button. Stop scrolling at: "Retrain Old User?".
- D. Press YES. You will now be prompted for your ID number. Enter the same number as before. The speech unit will now read: "Loading Patterns for user ID (your ID #)".
- E. After a minute or so, the speech unit will read: "All Grammars?". Always respond by pressing the NO button.

**NOTE:** If you press YES, you will be asking for a long exercise.

- F. The speech unit will read a menu (#4) of all ten (10) selections. Scroll through it with the NO button until you find a section you wish to train.
- G. When you find it, press the YES button.
- H. The speech unit will prompt you to Set the Gain. Do this exactly as before (Step # 8). Remember, be ready to start speaking immediately after pressing the YES button in response to the "YES to proceed" prompt. Examples of word combinations are listed in Enclosures (2).

- I. As in the ENROLLMENT phase, you will be able to use the STOP button for the same reasons as stated in Step #10.
- J. At the completion of each of the ten (10) training sections, the speech unit will read: "YES to save".
- K. Press the YES button.
- L. The speech unit will now read: "Patterns Saved. YES to Test".
- M. Press the YES button.

**\*\* NOTE \*\*** Test Sessions:

- 1. For each completed and saved training section (except "DISPLAY"), you will be prompted to say one word or phrase; usually it will be the word "Control\_K". Respond using the same annunciation and voice modulation as you did during training. The speech unit will score your training ability on a scale from 0 to 100. Acceptable scores range from 80 to 100. Lower scores are an indication that possible retraining is warranted.
  - 2. After the DISPLAY section is completed and saved, a similar but longer test will be given. Each response will be scored, as well as an average score given for that particular section. The test will take about 1 minute.
14. At the completion of each test session, the speech unit will read: "Score = \_\_\_\_\_. YES for Menu".
15. Press the YES button. The speech unit will now read: "Exits \_\_\_\_ ", then: "Add New User?" (Menu #1).
16. At this point if you would like to continue with another section of the TRAINING Phase, simply scroll through the Menu (using the NO button) until the speech unit reads: "Retrain Old User?". Now continue with step 13d.
17. If instead you would like to log-out at this point, scroll through the Menu until the speech unit reads: "Logout?". Press the YES button. The speech unit will now read (in respective order): "Exit ID (your ID #); "Logout supervisor" ("00"); and "Enter User ID".
18. If you decide to continue and interface with the NWISS wargaming scenarios, the system set-up will have to be modified in accordance with Figure #2, and then you can continue with step #20.

19. To shut the system down, simply place all of the individual power switches (On/Off switches) to the OFF position.
20. With the VT-102 and the ADM 31 establish the initial set-up as per procedure 1 (A-J). The speech unit should now read "Enter User ID:". Enter your ID number and press ENTER.
21. The speech unit will now read "Loading Patterns for ID = ".
22. You can set the gain (as per #8 - 10 ) either prior to or after the NWISS is brought online.
23. Upon completion of the game, press the STOP button. Scroll through the Menu #3, and follow steps 17 and 19.



## HELPFUL HINTS

1. Use the enclosed Wordlist as a guide while going through the ENROLLMENT Phase. It would also be very beneficial to have studied it prior to attempting the phase, as the words are presented too fast to think about pronunciation prior to speaking them.
2. Sit comfortably; preferably directly in front of the speech unit.
3. Be ready to push the STOP button if you make a mistake.
4. Study the word list (Enclosure 1) prior to enrolling. Especially consider the words in the "pronounce" column. Say them naturally. DO NOT pause for any word in the ENROLLMENT phase. The spaces in that column are to help determine the proper pronunciation of the word. It will be necessary to pause in the TRAINING phase, but only long enough to distinguish between words.

For example, ("FOR KITTY").

5. In general, use the most natural pronunciation that comes to mind.
6. Pronounce numbers which appear as part of fixed identifiers, in a natural manner (i.e. F14A as F Fourteen A; MK48 as Mark Forty-Eight, etc.).
7. Fully pronounce digits which appear as part of variable strings (i.e. Altitude 2500 as Altitude Two Five Zero Zero, etc.).
8. Be consistent with your pronunciations.
9. The Select YES/NO light:
  - A. This light is on the console of the speech unit. When it is illuminated it means press the YES or NO button as applicable.
  - B. **NOTE:** This procedure is only true if the speech unit reads a line of a " Menu ". At all other times, only the YES button will be accepted.

## MENU GUIDE

**NOTE:** Do not use the following list of ID numbers: 00 through 10 (inclusive), 47, 69 70 or 74

### MENU #1

This menu is invoked by entering the supervisor mode (i.e. 00 into the speech unit)

Add New User?

Test Old User?

Re-Enroll Old User?

Re-Train Old User?

List User?

Delete Old User?

Logout?

### MENU #2

This menu is invoked by by use of the STOP button within ENROLLMENT

Phase.

Resume Enrollment?

Reject Last Utterance?

Save Patterns?

Logout?

### MENU #3

Invoked by completing the test session in the TRAINING phase

Continue?

Calibrate?

Restart?

Logout?

### MENU #4

Invoked by commencement of the training

All Grammars?

NWISS1?

Force?

Display?

Position?

Track?

Fire?

Shiporder?

Airorder?

Digits?

Launch?

# WORDS TO BE TRAINED ON THE VERBEX

<u>WORD</u>	<u>PRONOUNCE</u>	<u>WORD</u>	<u>PRONOUNCE</u>
1. Execute		25. Wilso	WILSON
2. BAIRASW	B AIR ASW	26. Knox	NOX
3. BCAP2	BEECAP2	27. McCor	McCORMICK
4. ECAP1	BEECAP1	28. Kitty	KITTY
5. F14STRCAP	F FOURTEEN STRIKECAP	29. VT0	VEE TEE ZERO
		30. 0	ZERO
6. A6STRIKE	A SIXSTRIKE	31. 1	
7. Control_k		32. 2	
8. Force		33. 3	
9. Track		34. 4	
10. Position		35. 5	
11. Designate		36. 6	
12. Neutral		37. 7	
13. Friendly		38. 8	
14. Enemy		39. 9	NINE (not niner)
15. Display		40. VS0	VEE S ZERO
16. Bearing		41. VH0	VEE H ZERO
17. For		42. VE1	VEE E 1
18. 1POINT1	1.1	43. VE0	VEE E ZERO
19. Sprua	SPRUANCE	44. VW0	VEE W ZERO
20. Misawa	MISAWA	45. VK0	VEE K ZERO
21. Losan	LOS ANGELES	46. VF0	VEE F ZERO
22. Rathb	RATHBURN	47. VA0	VEE A ZERO
23. Omaha	OMAHA	48. SH1	S H 1
24. Wichi	WICHITA	49. MP6	N PEE SIX

50. Vlad		77. BAO	BEE A ZERO
51. Petro	PETRO	78. Tomhk	TOMOHAWK
52. Alexs		79. Hrpon	HARPOON
53. Wonsa	WANDSA	80. Cruise	
54. Erase		81. ASROC	AS ROCK
55. Plot		82. MK46A	MARK FORTYSIX A
56. LOB	L O B	83. MK46	MARK FORTYSIX
57. ESM	E S M	84. MK48	MARK FORTYEIGHT
58. Sonar		85. Torpedo	
86. Drop		86. At	AT (cne word)
60. Cancel		87. Range	
61. Grid		88. Orders	
62. Circle		89. Take	
63. XMARK	X mark	90. DECM	D E C M
64. All		91. Off	
65. Place		92. On	
66. Center		93. RBOCK	ARBOCK
67. Radius		94. Blip	
68. -	TACK	95. Launch	
69. N	NORTH	96. Weapons	
70. E	EAST	97. Free	
71. W	WEST	98. Submarine	
72. S	SOUTH	99. Surface	
73. BU0	BEE YOU ZERO	100. Air	
74. BS0	BEE S ZERO	101. Tight	
75. BP0	BEE P ZERO	102. EMCON	MCON
76. BE0	BEE E ZERO	103. Surf	SURF



104. AIRS	AIRS	130. SSQ62	S S C SIXTYTWO
105. AEW	A E W	131. SSQ53	S S Q FIFTYTHREE
106. Silen	SILENT	132. SSQ47	S S Q FORTYSEVEN
107. Radia	RADIATE	133. A6E	A SIX E
108. Fire		134. A7E	A SEVEN E
109. Station		135. E2C	E TWO C
110. Periscope		136. EA3B	E A THREE E
111. Depth		137. EA6B	E A SIX B
112. Course		138. F14A	F FOURTEEN A
113. Speed		139. F14T	F FOURTEEN T
114. Proceed		140. KA6D	K A SIX D
115. Barrier		141. P3C	PEE THREE CEE
116. Mission		142. S3A	S THREE A
117. ASW	A S W	143. SH3H	S H THREE H
118. SURCAP	SIRCAP	144. SH2F	S H TWO F
119. Search		145. HARP	HARP
120. CAP		146. MK82	MARK EIGHTYTWO
121. Airtanker		147. MK83	MARK EIGHTYTHREE
122. STRCAP	STRIKECAP	148. MK84	MARK EIGHTYFOUR
123. Strike		149. Phenx	PHEENIX
124. Cover		150. Shrik	SHRIKE
125. Altitude		151. Spar	SPARROW
126. Bingo		152. Swdr	SIDEWINDER
127. Refuel		153. Walli	WALLEYE
128. VK00	VEE K ZEROZERO	154. Load	
129. SQ538	S Q FIVE THIRTYEIGHT	155. Stop	

ENCLOSURE (1)

# TRAINING PHASE: EXAMPLES OF WORD COMBINATIONS

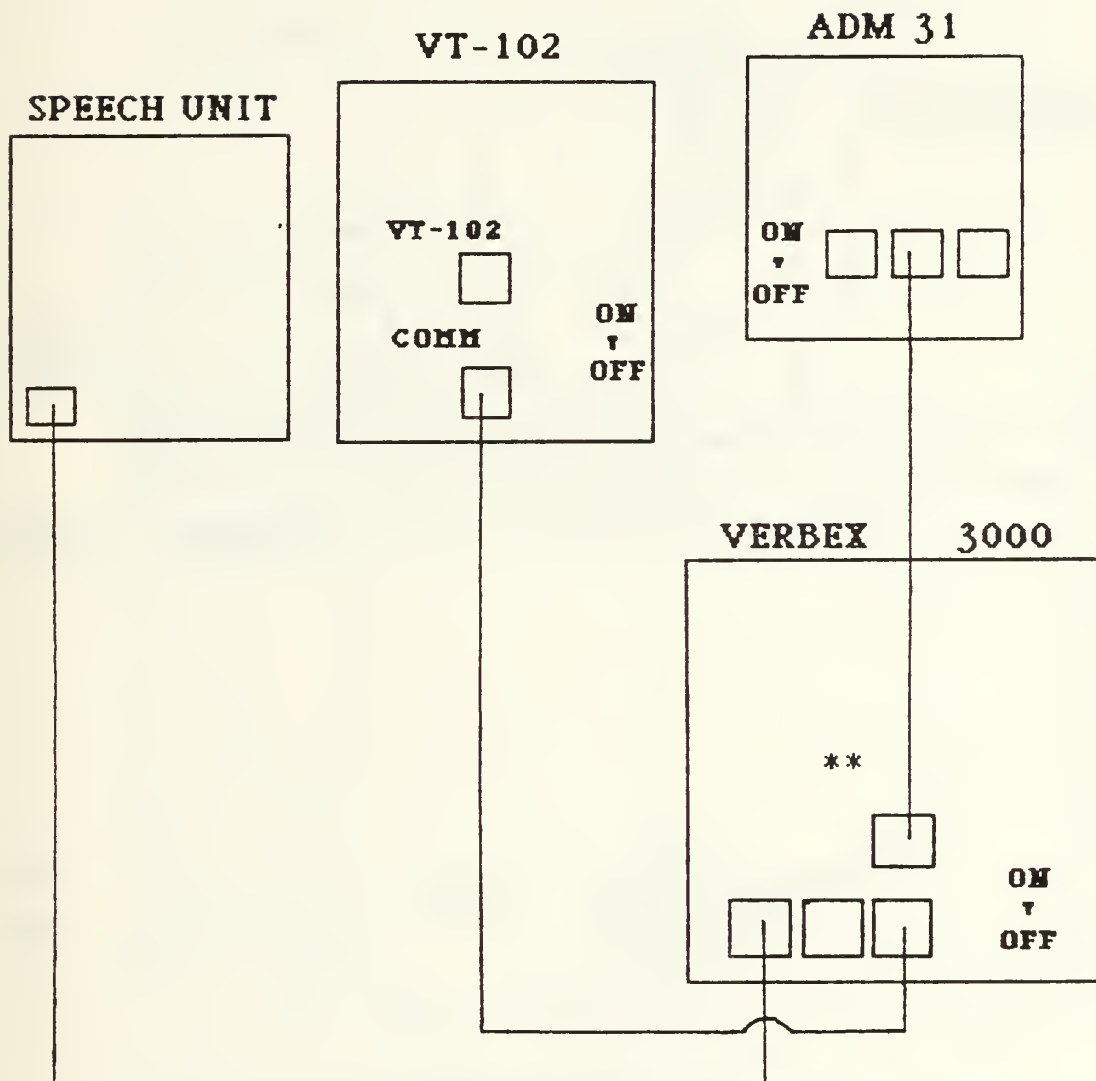
<u>NWISSGRAM1</u>	<u>FORCE</u>	<u>DISPLAY</u>
Bearing Track	VE-100	Radius 3 4
BS-008	VF-101	1 9 5
VT-001	VK-003	Erase LOB ESM
BAIRASW	VF-025	Plot LOB Sonar
Designate Neutral	VH-004	Cancel Circle All
Display	Spruance	Place Grid Track
Execute Fl4STFCAP	Aleks	Center Force
VF-068	Vlad	Cancel Circle Posit
Position	Misawa	Place Grid Force
SH-105	Wilson	Place XMark Force
For lPointl	MP-600	Place XMark Posit
For Knox	Rathburn	Center Position

<u>POSITION</u>	<u>TRACK</u>	<u>FIRE</u>
- 35	BU-059	8 4 9
5 - 5	BU-009	2 Tomhk Cruise
2 8 W	BE-026	Bearing 5 7
1 8 E	BA-034	3 ASROC Torpedo
1 3 4	BP-047	At Aleks
4 0 S	BS-012	At Wonsa
7 9 -	BE-039	1 5 0
6 - 2	BA-057	2 Tomhk Cruise
- 35	BP-065	4 Hrpn Cruise
9 7 -	BS-017	5 MK46A Torpedo

ENCLOSURE (2)

<u>SHIPORDER</u>	<u>AIRORDER</u>	<u>DIGITS</u>	<u>LAUNCH</u>
Free Enemy Surf	Free Enemy Air	SQ-538	KA6D F14A 7
Course 4 5	Weapons Tight	0 8 9	0 6 MK46A
D E C N Off	Bingo	6 5 1	Proceed Posit
Speed 3 2	Refuel VK-000	SSQ-53	E2C S3A 8
Weapons Tight	6 7 8	5 6 4	A7E A6E 5
1 C	Mission Strike	Control_K	3 2 Sidewndr
Free Enemy Sub	Speed 4 9	3 7 5	0 4 SSQ-62
9 1 7	Mission Cap	SSQ-47	Stop
ARBOC	Mission AEW	1 6 0	2 1 MK 84
Free Enemy All	Cover	2 4 6	F14A SH2F 7
D E C M On	Mission Search	8 3 6	KA6D F14T 9
Course 5 4	Mission Strkcap	9 4 5	4 3 SQ538

Configuration to Train  
Voice Patterns on  
the Verbex 3000

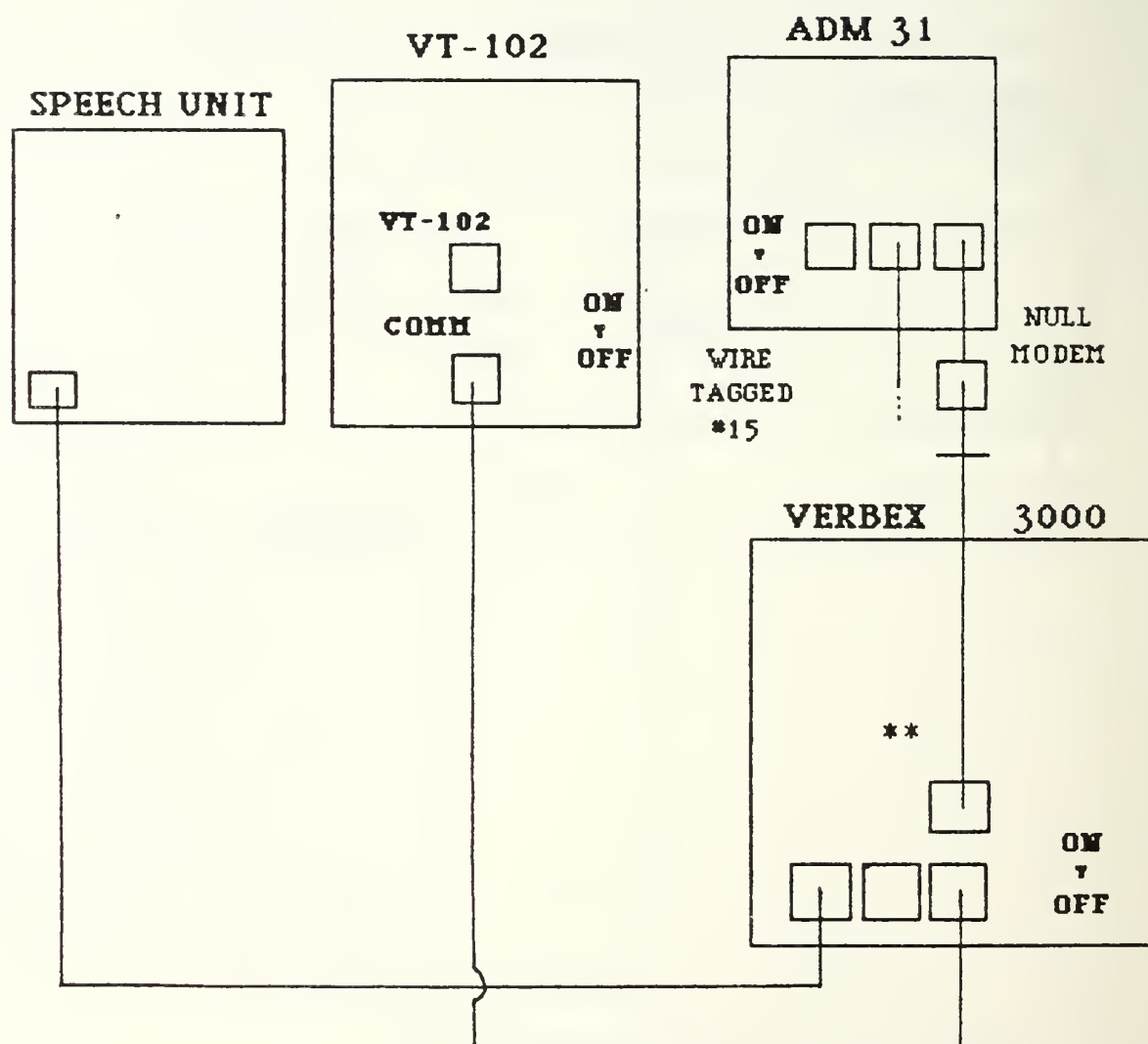


\*\* : THE ADAPTER IS STAMPED: " VERBEX ONLY ".

**NOTE:** THE DIAGRAM DEPICTS VIEWING THE MACHINES FROM THE REAR.

FIGURE #1

Configuration to Run  
NWISS on the  
Verbex 3000



\*\* : THE ADAPTER IS STAMPED: " VERBEX ONLY ".

**NOTE:** THE DIAGRAM DEPICTS VIEWING THE MACHINES FROM THE REAR.

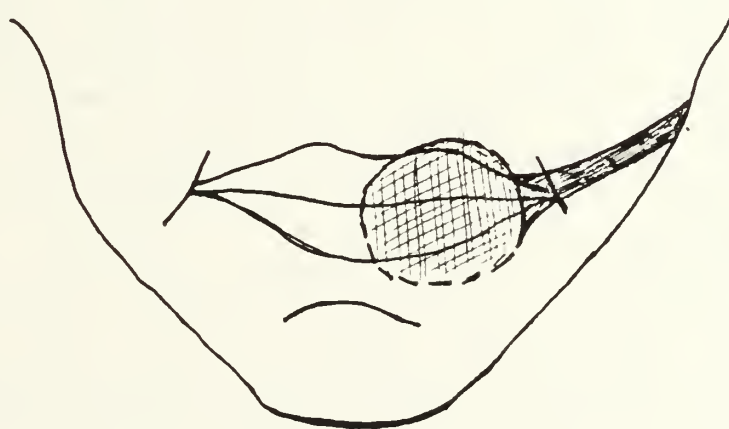
FIGURE #2





**NOTE:**

MICROPHONE POSITION IS CRITICAL, THE MICROPHONE SHOULD BE NO MORE THAN 1/2 INCH FROM THE LIPS WITHOUT TOUCHING THEM. (I.E. AS SHOWN IN THE FIGURE ABOVE)



THE MICROPHONE POSITION SHOULD BE **ONLY SLIGHTLY** LOWER THAN THE CENTER OF THE MOUTH.

**FIGURE #3.**

## APPENDIX G

### MACINTOSH MICROCOMPUTER USERS GUIDE

The purpose in accomplishing this training is to prepare to play various NWISS Wargame Scenarios as an Aircraft Carrier Battle Group Commander during the course of the individual record trial. Commands for the game will be entered using the point select method to build acceptable commands in the place of a conventional keyboard.

To accomplish the necessary training, utilize the following steps to attempt to gain some skill in building commands:

1. Reach around to the left side of the MAC, and turn it on using the rocker switch on the upper left side of the back. Place the mini-disk, label up, in the slot on the lower right of the front, with the metal tab entering the slot first. (NOTE: It is not necessary to open the tab first as it is done automatically by the drive.) Wait for the system to load itself (which may take a little over a minute).

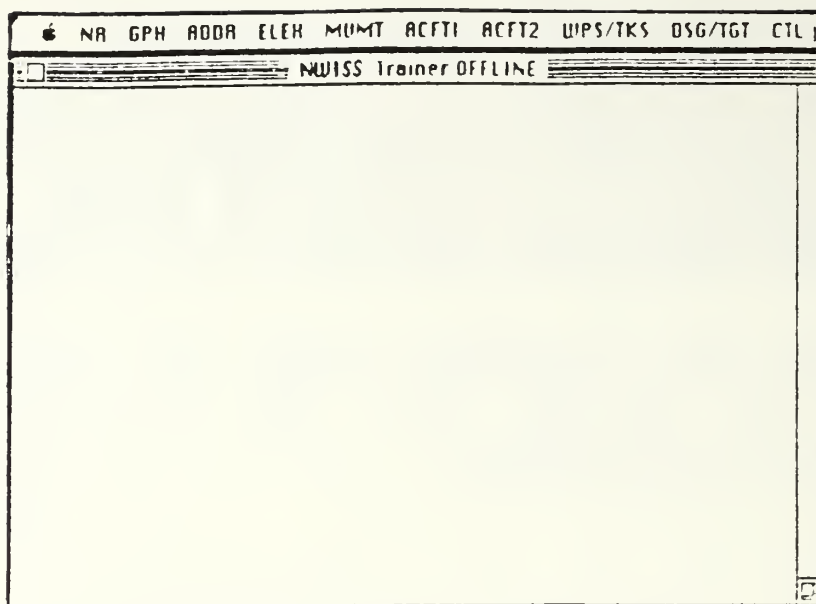
2. You will see a desk top with two or more file icons. Using the mouse, move the arrow to the icon labeled "Offline Training", and with the arrow placed anywhere on the icon, click the mouse button twice. The program, which conditions the MAC as an NWISS terminal, will now load and run itself.

3. When the load is complete you will see a series of column headers along the top of the desk top (i.e. "NR" contains numbers, etc.). At this point you are actually corresponding with a program written in BASIC. This program provides menus of command words from a limited vocabulary. It supports sequential selection of these words and their associated display (in an orderly fashion on the screen) in order to allow the build-up of full commands. The program also accomplishes communications with the VAX and returns information from the VAX to the screen; similar to the output provided by the VT100 terminal. To select a word from a menu use the mouse to position the arrow on the menu title along the top of the screen, push down the mouse button, **and hold it down**. The menu will extend downward in its own window (see the attached example menus). Continue to hold the mouse button down while you move the mouse to position the arrow on the word of your choice. When the arrow is over each word it will be highlighted. To select one of the words simply let up on the button. The window will disappear and the word will be displayed on the desk top. **When a command is complete, move to the right-most column and select "EXECUTE ORDER" from this menu.** The VAX will respond to the order when the system is "on-line" in the future, but

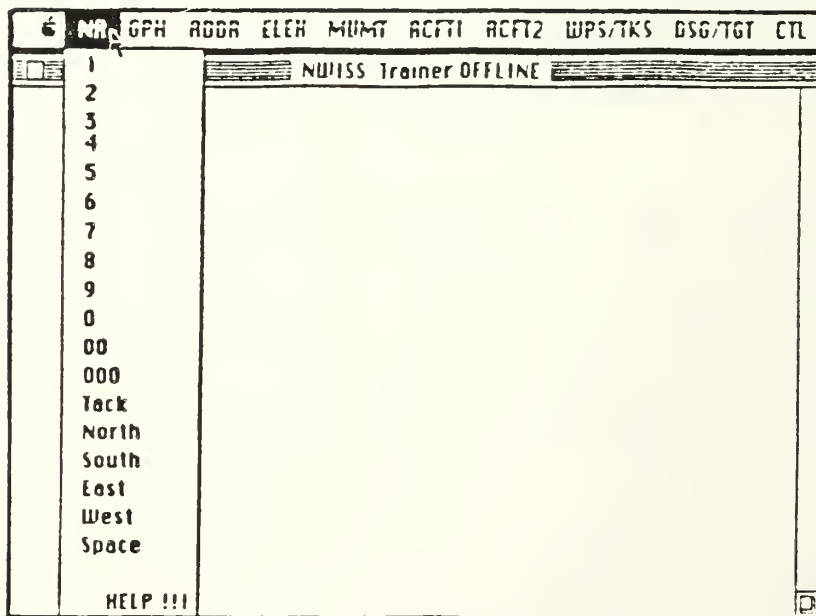
realistic practice sessions can still be obtained in the "off-line" mode.

4. Notice that the right-most menu contains a selection for "MANUAL ENTRY". This allows you to type in the words that are otherwise not on the menus. The key under your left palm with an infinity sign is the control key. Use the delete key to back out errors in this mode. Once you have selected this mode, you must then type your desired word and close the session with an "\*" which will take you back to mouse control. Now "EXECUTE ORDER" must be selected from the last menu in order to complete the command.

5. To terminate the session, select "QUIT PROGRAM" on the right most menu. At the next window under the FILE menu select "QUIT", and under the next window under the FILE menu select "EJECT". When the mini-floppy disk is ejected, turn the machine off with the switch in the back.

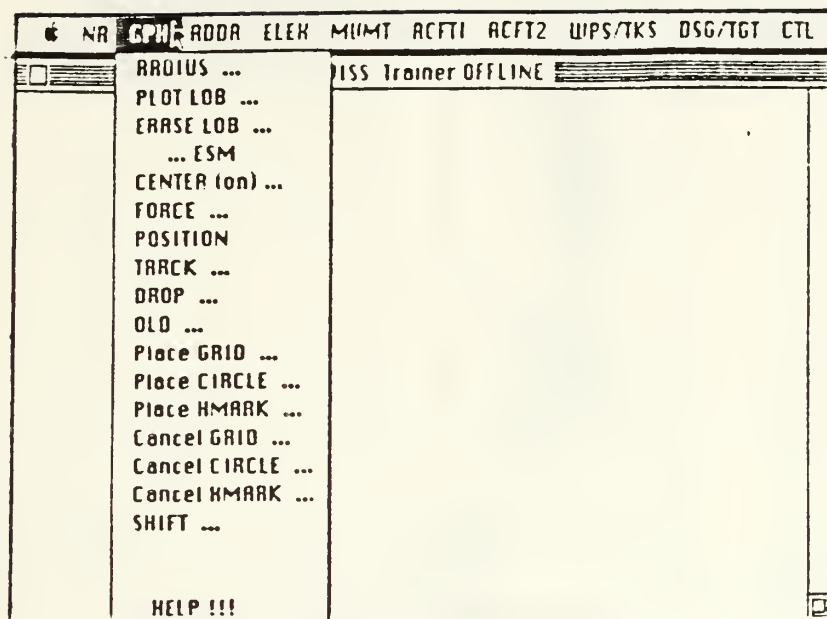


BASIC SCREEN

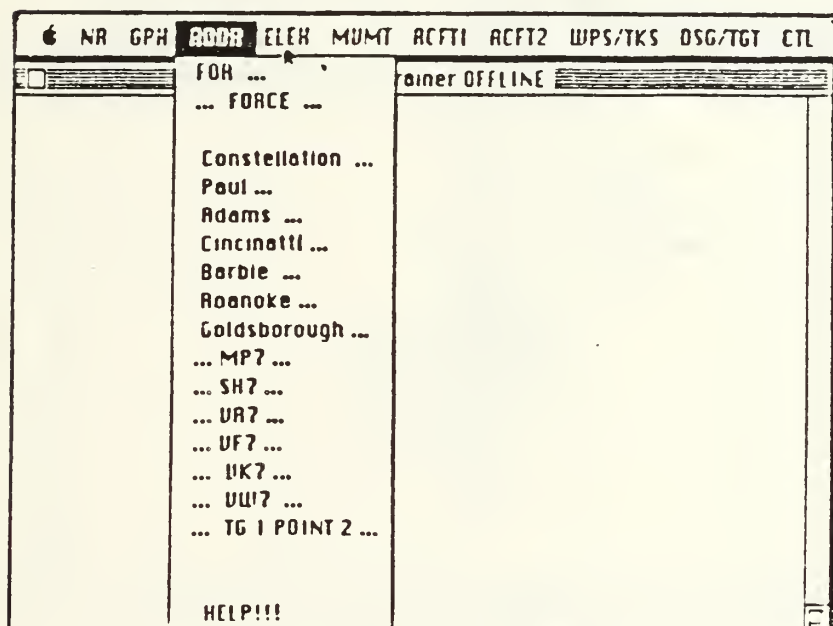


NUMBER MENU

ENCLOSURE 1

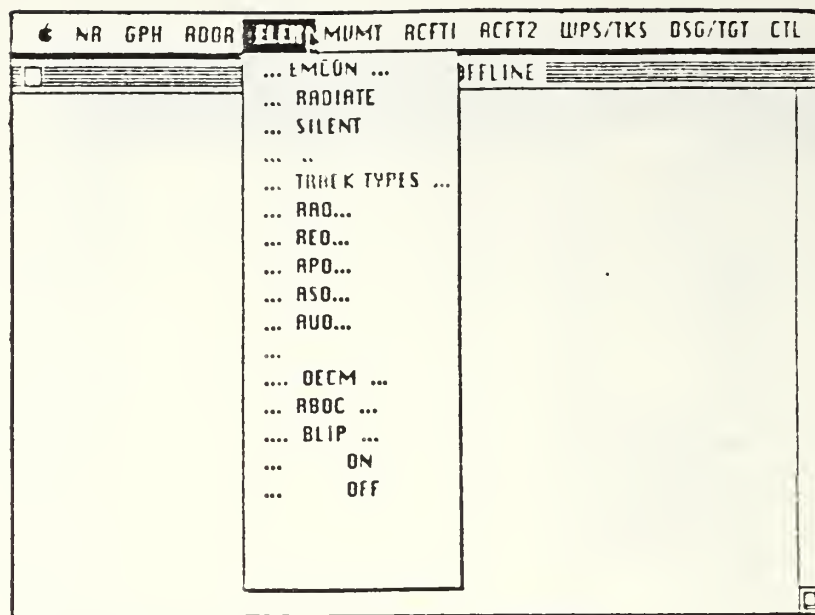


GRAPHICS MENU

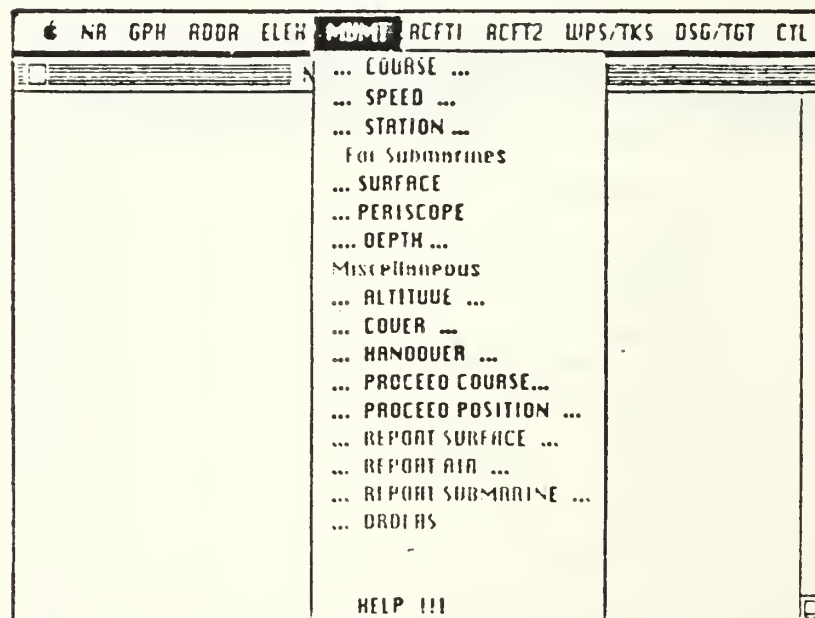


ENCLOSURE 2



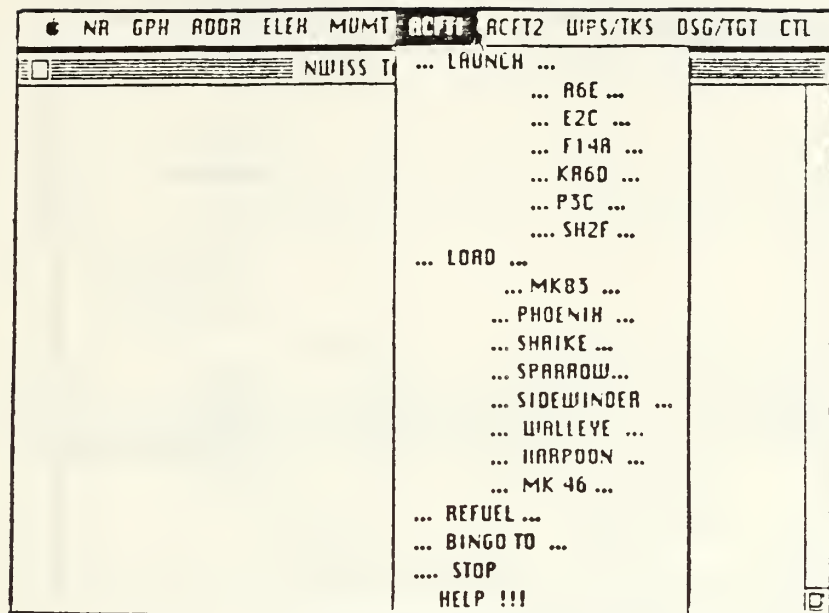


ELECTRONIC MENU

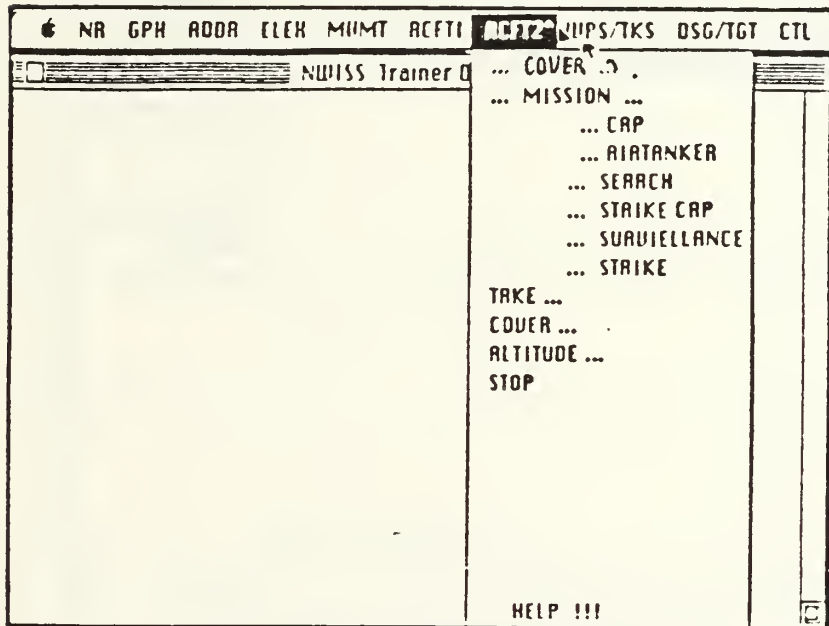


MOVEMENT MENU

ENCLOSURE 3

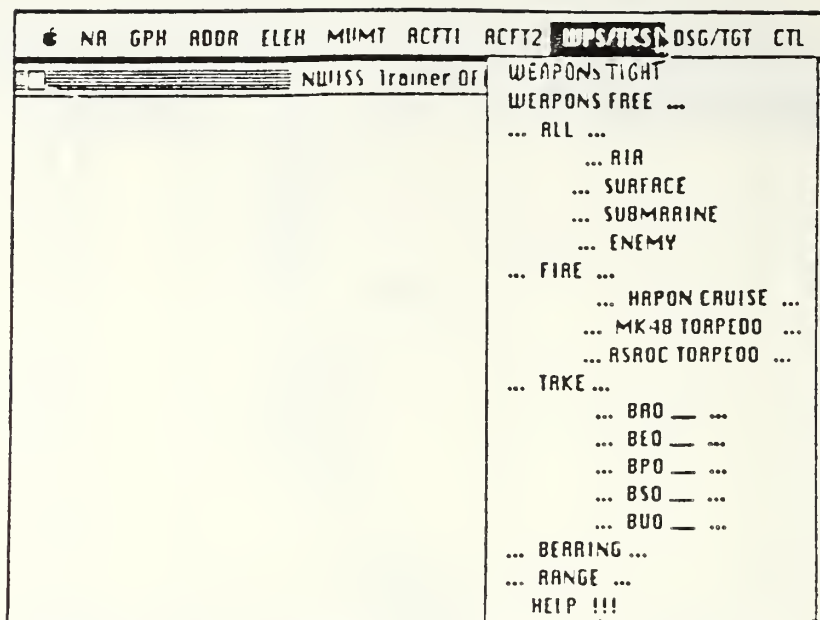


AIRCRAFT1 MENU

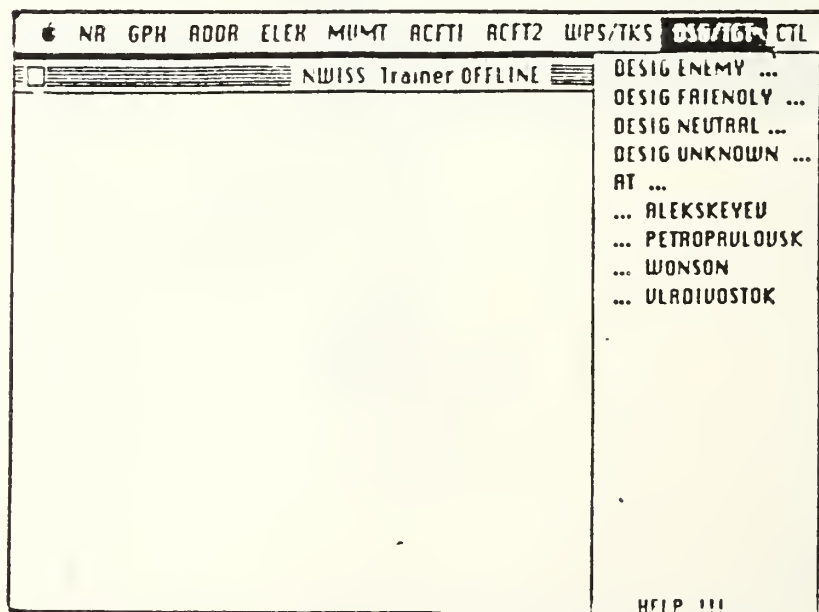


AIRCRAFT2 MENU

ENCLOSURE 4

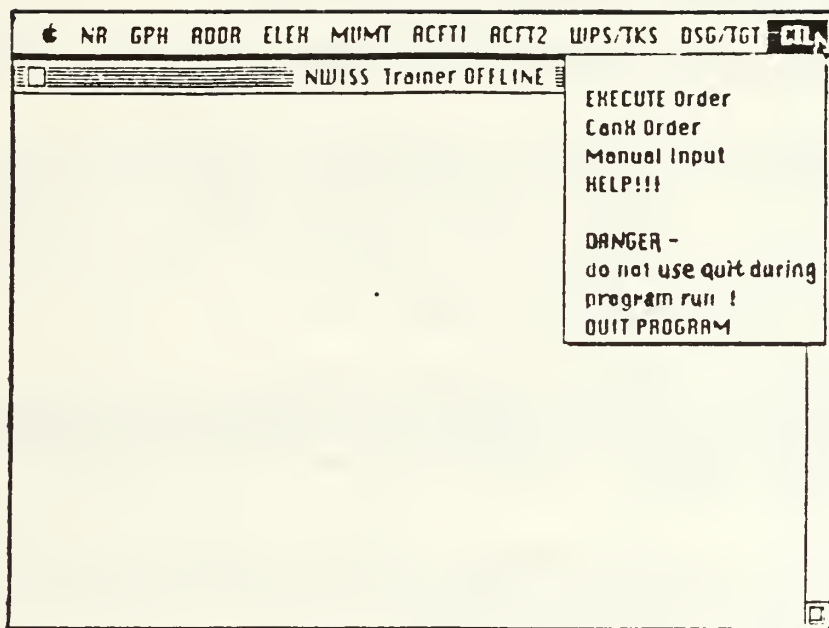


WEAPONS/TRACK MENU



DESIGNATING TARGET MENU

ENCLOSURE 5



CONTROL MENU

ENCLOSURE 6

## LIST OF REFERENCES

1. Dixon, N. Rex, and Martin, Thomas E., Automatic Speech and Speaker Recognition, IEEE Press, 1979.
2. Wright, Michael E. and Manson, Rick B., Comparison of Continuous Speech, Discrete Speech and Keyboard Input to an Interactive Warfare Simulation in Various C3 Environments, Master's Thesis, Naval Postgraduate School, Monterey, California, March 1985.
3. Guterl, Fred, "Design Case History: Apple's Macintosh", IEEE Spectrum, pp. 34-43, December 1984.
4. White, George M., "Speech Recognition: A Tutorial Overview," Computer, vol. 9, pp. 40-53, May 1976.
5. White, George M., "Speech Recognition: An Idea Whose Time Is Coming," BYTE, pp. 213-222, January, 1984.
6. Lea, Wayne A., "Speech Recognition: Past, Present, and Future," Trends In Speech Recognition, ed. Wayne A. Lea, pp. 39-98, Prentice-Hall, 1980.
7. Perceptronics Report, Initial Comparisons Among Continuous Speech, Discrete Speech, and Keyboard Operation of an Interactive Warfare Simulation in Various C3 Environments, by Jay E. Martin, April 1985.
8. Lombardo, John, Using Continuous Voice Recognition Technology as an Input Medium to the Naval Warfare Interactive Simulation System (NWISS), Master's Thesis, Naval Postgraduate School, Monterey, California, June 1984.
9. Naval Postgraduate School Report No. NPS55-83-033, A Review of Selected Studies of Computerized Speech Recognition Conducted at the Naval Postgraduate School, by Douglas E. Neil, November 1983.
10. McSorley, William J., Using Voice Recognition Equipment to Run the Warfare Environmental Simulator, Master's Thesis Naval Postgraduate School, Monterey, California, March 1981.
11. Moritz, Michael, "Apple Launches a Mac Attack", BYTE, pp. 68-69, January 30, 1984.
12. Williams, Gregg , "The Apple Macintosh Computer", BYTE, pp. 30-39, February 1984.



13. Freiburger, Paul and Swaine, Michael, Fire in the Valley: The Making of the Personal Computer, Osborne/McGraw-Hill, 1984.
14. Verbex, Division of Exxon Enterprises: SPADS, Designer's Manual for the Verbex 3000 (Preliminary), October 1983.
15. Owens, James D. and Brown, Garland B., An Investigation of the Impact of Headquarters Structures on the Military Command Environment, Master's Thesis, Naval Postgraduate School, Monterey, California, March 1984.
16. Hicks, Charles R., Fundamental Concepts in the Design of Experiments, Holt, Rinehart, and Winston, 1973.
17. Bradley, James V., Probability; Decisions; Statistics, Prentice-Hall, Inc., 1976.
18. Naval Postgraduate School Report No. NPS55-80-016, Experiments with Voice Input for Command and Control: Using Voice Input to Operate a Distributed Computer Network, by Gary K. Poock, April 1980.
19. Martin, B. Jay, Draft Report to Perceptronics (unpublished)
20. Larson, Harold J., "Introduction to Probability Theory and Statistical Inference," pp. 492-499, Wiley and Sons, 1982.
21. Ryan, Thomas A. Jr., Joiner, Brian L., and Ryan, Barbara F., Minitab Student Handbook, PWS Publishers, 1976.

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